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COST OF MONITORING AIR QUALITY IN THE UNITED STATES

A. K. Miedema, et al

Research Triangle Institute

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16. ABSTRACT

Two sets of aggregate national air quality monitoring costs are estimated. The first set projects the costs of implementing the minimum federal air quality surveillance requirements. It is estimated that $3.2 million incremented capital will be necessary to complement existing instruments if such a network is to become operative in 1974. The annualized cost to operate the network is estimated to be $12.8 million.

The second set projects costs of implementing the state-proposed networks. An incremental capital cost for instruments is estimated to be $12.6 million to complement existing networks. The annualized cost to operate the proposed networks is $36.9 million.

Analysis of portable and automated air quality monitoring stations indicate that telemetric stations are less costly than logging systems.

An extensive table of costs for each state is included.

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Research Triangle Park, North Carolina

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COST OF MONITORING AIR QUALITY IN THE UNITED STATES

CHAPTER 1: INTRODUCTION AND SUMMARY

The purpose of this report is to present the best available estimates of the costs of monitoring ambient air quality in the United States. The costs estimated herein include not only projected expenditures for air sampling instruments but also those for sampling site operation, maintenance, and instrument replacement. Estimates are presented for each State and U.S. territory on the basis of two sets of projected demand. One is based on the minimum requirements of Federal regulations, and the other on systems proposed by the States themselves.

1.1 Background

The setting of national air quality standards pursuant to the Clean Air Act Amendments of 1970 (hereafter the Act) set the stage for national air monitoring requirements. Section 109 of the Act (P.L. 91-604, December 31, 1970) required the Administrator of the Environmental Protection Agency (EPA) to propose national primary and secondary ambient air quality standards for each air pollutant for which air quality criteria had been issued prior December 31, 1970. Those air pollutants included sulfur oxides (SO_x), particulate matter (PM), carbon monoxide (CO), photochemical oxidants (O_x), hydrocarbons (HC), and nitrogen dioxide (NO_2). On April 30, 1971, the proposed standards were promulgated by the Administrator of the EPA in the Federal Register (42 CFR 410).

The Act delegated the primary responsibility for the prevention and control of air pollution to the State and local governments. Section 110 of the Act required each State to submit to the EPA an implementation plan whose general purpose was to describe the methods to be used by each State in implementing, maintaining, and enforcing the promulgated air quality standards. That section specifically required that "it [the implementation plan] include provision for the establishment and operation of appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile, and analyze data on ambient air quality, and (ii) upon request, make such data available to the Administrator."

Under his regulation-making authority, the Administrator of EPA promulgated regulations for the preparation, adoption, and submittal of those implementation plans. The regulations, published on August 14, 1971, in the Federal Register (42 CFR 420), include minimum requirements on the number of air quality monitoring instruments that had to be proposed for the measurement of ambient concentrations of each pollutant. The minimum requirements (see appendix A) vary according to the priority classification of the identified air quality control regions within the States. The priority classifications (I, II, or III) are based on "measured ambient air quality, where known, or, where not known, estimated air quality in the area of maximum pollutant concentration."* Within the most polluted regions (priority I), the required number of stations for each pollutant varies according to population.**

In addition, the implementation plans were required to "provide for the establishment of an air quality surveillance system which shall be completed and in operation ... not later than two years after the date of the Administrator's approval of the plan." This effectively requires operational monitoring systems by mid-1974. In the November 25, 1971, issue of the Federal Register (40 CFR 50), the Administrator of the EPA issued a detailed listing of the reference methods for the measurement of ambient pollutant concentrations. These reference methods or their equivalents are acceptable for the purpose of meeting the implementation plan requirements.

The approved State implementation plans (SIP's) included an inventory report on the number and type of stations that are currently in operation in each region. Furthermore, they included the number of air quality monitoring instruments of each type that are proposed to meet the requirements of the Act. A summary of those data and of the required number of stations are reported on an aggregate nationwide basis in Table 1-1.

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* Federal Register (42 CFR 420), August, 1971, §420.3.

** ibid., §420.17.

Table 1-1. NATIONWIDE SUMMARY OF STATE MONITORING INVENTORIES AS REPORTED IN STATE IMPLEMENTATION PLANS (SIP'S)

Pollutant/Method	Number of monitors			
	1971 Existing	1974 Proposed	Legal requirement	Percent increase*
PM/tape	397	901	497	127
PM/Hi-vol	2,538	3,511	1,366	38
SO_2/continuous	329	698	213	112
SO_2/bubbler	541	1,431	666	164
O_x/continuous	183	458	208	150
CO/continuous	197	457	133	132
NO_2/continuous	118	314	0	166
NO_2/bubbler	370	876	425	136
Total	4,673	8,646	3,508	85

*1974 Proposed/1971 Existing.
Source: Environmental Protection Agency.

1.2 General Approach

The first step in the analysis was to identify the purchase, operating, and maintenance costs associated with each sampling instrument. These estimates were based on the assumption that each State collected the minimum number of samples required by the EPA (see appendix A). Section 2.1 of chapter 2 reports those estimates along with a brief discussion of the assumptions regarding individual cost parameters.

Section 2.2 in chapter 2 indicates other air monitoring network costs that were not directly assignable to the operation of specific instruments. These include shelter construction and site maintenance costs, data processing costs, transportation costs, system design and administration costs, and equipment replacement costs.

Chapter 3 indicates the method used to compute air quality monitoring costs among States from the cost factors estimated in chapter 2. Also, the final cost estimates are reported there

according to state and for the nation. These costs are estimated for both the state-proposed and the federally required network of monitoring instruments, taking into account existing instruments.

In chapter 4, two topics of special interest are addressed: cost and operating characteristics of both telemetric and portable air quality monitoring instrumentation. Because of the need for current data on all alternative air quality monitoring systems, RTI conducted personal interviews with air pollution control agency personnel in Pittsburgh, Pennsylvania, and Chattanooga, Tennessee, and telephone interviews with other local agency personnel regarding the automated air quality reporting systems installed in those regions. Since they are relatively new systems, the cost data are thought to be quite accurate. Further information on portable monitoring sites was gathered from these agencies and from RTI field applications of air quality monitoring technology. The results of these analyses are discussed generally in chapter 4. No attempt is made there to supplement the cost estimates of chapter 3. The cost factors provided there are, however, reasonable inputs for an analysis of alternative air quality monitoring systems in selected regions.

1.3 Summary of Findings

Two sets of aggregate national air quality monitoring costs were estimated. The first set projects the costs of implementing the minimum federal air quality surveillance requirements (see Appendix A). The costs of this required network are reported in Table 3-3. It is estimated that an incremental capital outlay of about $3.2 million will be necessary to complement already existing instruments if such a network is to become operative in 1974. The annualized cost of operating such a network, once completed, is estimated at $12.8 million.

The networks separately proposed by the states are substantially larger and more expensive than the minimum federal requirements dictate. It is estimated that the state-proposed networks will require an incremental capital outlay of $12.6 million to complement existing networks. The corresponding, nationally aggregated estimate of the annual cost of operating the state-proposed networks is $36.9 million. In other words, the proposed systems would be about three

times as costly as those systems which meet the minimum federal requirements.

The analyses of portable and automated air quality monitoring stations indicate that telemetric networks are less costly than a data logging system (one which involves the recording of air quality data on magnetic tape and transferring it to a central station for processing). The difference in costs between these two systems becomes larger as either the number of samplers per station or the number of remote stations increases. Finally, with respect to portable stations, it was determined that considerable monitoring flexibility can be offered by portable sampling stations with a modest increment in initial capital outlays.

CHAPTER 2: ESTIMATION OF AIR QUALITY MONITORING NETWORK COST FACTORS

Estimating the costs of installing and operating air quality monitoring instruments requires a detailed understanding of both technical and economic aspects of instrument design and operation. It is the purpose of this chapter to provide an overview of those considerations for each of the eight subject instrument types and for other network costs not assignable to the installation and operation of particular instruments. The estimates presented in this chapter are only approximations based on RTI's best judgement. Despite the fact that some of the estimates, e.g. labor costs, are imprecise for specific states or locales, it is felt that, in the aggregate, the cost factors estimated here reflect reasonably accurate assumptions.

Within the category of instrument related (section 2.1) and other network related (section 2.2) costs two types of cost items can be identified: initial capital (investment) requirements and annual costs. The initial capital requirements can be regarded as the projected incremental cash outlays that are needed in each state or region to make the air quality monitoring network operable. In chapter three these capital requirements are projected separately based on the cost factors presented here. The alternative cost breakdown, also reported in the next chapter, gives annual costs. These include both an annualized portion of capital requirements and other variable costs associated with the operation and maintenance of an air quality monitoring network. The methods of computing each of these items are specifically noted in the following paragraphs.

2.1 Instrument Purchases, Operating, and Maintenance Costs

The major portion of air quality monitoring network costs is related to the purchase and operation of the monitoring instruments themselves. This section first presents an overall discussion of the cost items associated with each instrument. Then the cost factors estimated for each instrument are discussed and presented in tables 2-1 through 2-8.

2.1.1 Cost Categories

The cost categories identified for each instrument were capital costs, normal operating costs, maintenance and repair costs, and supervision and quality control costs.

2.1.1.1 Captial Costs. The capital or investment requirements include the initial purchase cost of the sampling device as well as the cost of tape readers and strip chart recorders, where appropriate. Also included are the initial purchase cost of ancillary equipment such as sampling manifolds, ports, etc. A third category of purchases included as a capital cost is the investment in instrument calibration kits, where required. Finally, the costs of time and materials necessary for equipment installation complete the group of items representing capital costs. Based on assumptions detailed in succeeding paragraphs, these capital costs are then amortized to yield an estimate of annual costs attributable to initial equipment purchases and installation.

2.1.1.2 Normal Operating Costs. Generally, this category of costs includes all non-maintenance related costs of operating the sampling devices, collecting the samples (not including travel time and mileage to and from the site), and analyzing the samples. The major cost items include: electric power charges; filters, tape, recorder paper, and reagent costs; calibration and operational checking; sample analysis; and data reduction. All these costs are variable and are therefore entered as annual cost items. Hourly labor charges are burdened rates, i.e. they include an allocation for overhead charges, including facilities rental costs, salary fringe benefits, etc.*

2.1.1.3 Maintenance and Repair Costs. This category incorporates estimates of the cost of replacement parts and of time costs for proper sampler maintenance. These estimates reflect RTI's best judgement of the basic requirements for implementing good operating practices within an air quality monitoring network. However, it is recognized that a substantial degree of variation may occur among individual states in observing these maintenance practices.

2.1.1.4 Supervision and Quality Control. The final cost category encompasses the personnel requirements for the supervision of data handling and for the implementation of a quality control program. The

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*The burdened hourly rates used in this report are based on RTI's experience in operating air quality monitoring instrumentation and on reference to Richard H. Schulze, "The Economics of Environmental Quality Measurement," Journal of the Air Pollution Control Association, XXIII, No. 8 (August, 1973), 671-75.

supervision of data handling includes such items as reviewing calculations, validating data, and preparing periodic data reports for submission to either the EPA central or regional headquarters. The projected requirements for quality control checks are based on RTI's experience in operating each of the instruments to which the discussion now turns.

2.1.2 Particulate Matter High Volume Sampler

The estimated initial cost for a high volume particulate sampler, including a filter holder, an aluminum shelter and a seven-day timer is $225. Other initial capital costs include a calibration kit and installation costs. All together, capital requirements are projected at $410.

Electricity costs are expected to average $40 annually and sampler filters are likely to cost about $25 per year, assuming 61 samples are required annually. Sample analysis costs include time requirements for screening filters to remove those that are defective, for logging the filter in and for drying, weighing and identifying it before sending it to the field, for performing those same operations when it is returned to the laboratory and for calculating and coding the measured average particulate concentration over the 24-hour sampling period. Together these operations are expected to require thirty minutes per sample of a technician's time. Using the $9/hr. burdened rate yields an estimated laboratory sample analysis cost of about $275 per year per hi vol sampler.

A third category of costs associated with the operation of a hi vol included maintenance and repair parts. Sampler maintenance requires the replacement of brushes about every 25 days of operation as well as instrument calibration and checks on flow rates. Including two hours per year for emergency repair time, the requirements for maintenance are expected to be about 15 hours per year of a technician's time. At the $9 per hour burdened rate these costs would be about $135 per year. The annual cost of replacement parts (brushes, motors, etc.) are estimated at 20 percent of annual operating costs excluding travel costs.

Finally, operating a hi vol sampler requires supervision and quality control. Reviewing calculations and validating data for submission to the appropriate processing center are expected to require approximately 8 hours per year of a supervisor's time or about $160 per year at a $20

Table 2-1. PARTICULATE MATTER HIGH VOLUME SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital costs*		
High volume sampler with 8"×10" filter holder, alumninum shelter, and seven-day timer	$225.	$ 45.
Calibration kit†	85.	2.
Installation		
Power drop	50.	10.
Labor and stand	50.	10.
II. Normal operating costs		
Electric power		40.
Filters		25.
Sampling (20 minutes per sample, 61 samples per year, $9 per hour)		183.
Sample analysis (30 minutes per sample, 61 samples per year, $9 per hour)		275.
III. Maintenance and repair		
Sampler maintenance (15 hours per year, $9 per hour)		135.
Replacement parts (20 percent of costs in II)		105.
IV. Supervision and quality control		
Supervise, review, validate and report data (8 hours per year, $20 per hour)		160.
Quality control check at stations 8 hours per year, $18 per hour)		144.
Totals	$ 410.	$1,134.

*Capital costs are amortized over a five-year period in equal installments.

†Cost amortization assumes one kit is required for approximately every eight high volume samplers.

Source: Research Triangle Institute.

per hour burdened rate. Quality control costs will require about eight hours of a chemist's time annually to recheck about seven percent of the samples and to visit each sampler twice a year. Total annual costs of hi vol operation, reported in Table 2-1, are $1134.

2.1.3 Particulate Tape Sampler

Particulate tape samplers with an automatic spot evaluator and strip chart recorder cost approximately $1000. In addition to an estimated $25 for installation the initial installed purchase cost for this instrument is estimated at $1025 as reported in Table 2-2. Operating costs include expenditures for electric power, sampler tapes, and strip chart recorder paper which, given the federal sampling requirements (Appendix A), are expected to cost $40, $25, and $85 per year, respectively. Collection of the samples and the installation of new tapes is projected to require an average of ten minutes per working day per sampler of a technician's time. Reading the strip charts and transcribing the particulate concentration data are projected at 364 hours per year per tape sampler. At a burdened hourly rate of $9.00 these personnel operating costs sum to $3666 per year, by far the largest component of annual costs associated with the particulate tape sampler.

Maintenance and repair costs, including equipment calibration and replacement parts, are expected to cost $618 per year. Supervision and quality control are estimated at $360 apiece annually.

The summary data, reported in Table 2-2, indicate an initial capital requirement of $1025 for each tape sampler and annual operating costs of $5359.

2.1.4 SO_2 Gas Bubbler Sampler

The initial purchase cost of an SO_2 bubbler-type gas sampler with a shelter and timer was estimated at $400. Without the shelter the estimated cost was $325. These estimates are based on the current price lists for a Research Appliance Corporation (RAC) sampler. In addition, sample tubes, orifice tubes, etc. were estimated to cost $3 per sample or, since 61 samples are required annually, $183 per year. Incorporating an estimated $50 for installation costs yields an estimated total initial outlay of $633 for each new SO_2 bubbler sampler.

Table 2-2. PARTICULATE TAPE SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital costs*		
Tape sampler with reader and recorder	$ 1,000.	$ 200.
Installation (assuming preexisting shelter	25.	5.
II. Normal operating costs		
Electric power		40.
Tapes ($2.20 per roll)		25.
Recorder paper ($5.50 per roll)		85.
Sampling (10 minutes per day, 260 days per year, $9 per hour)		390.
Sample analysis (read charts and transcribe data; 364 hours per year, $9 per hour)		3,276.
III. Maintenance and repair		
Sampler maintenance, calibration, etc. (52 hours per year, $9 per hour)		468.
Replacement parts		150.
IV. Supervision and quality control		
Supervise, review, validate, and report data (18 hours per year, $20 per hour)		360.
Quality control (20 hours per year, $18 per hour)		360.
Totals	$ 1,025.	$ 5,359.

*Capital costs are amortized over a five-year period in equal installments.

Source: Research Triangle Institute.

Electricity and reagents are expected to cost $90 per year in operating each SO_2 bubbler. Personnel requirements include sample pick-up, analysis, and data recording. Together these activities will require about fifty minutes per sample, on the average. Given the necessary skill requirements, as indicated in Table 2-3, personnel operating costs will average about $610 per sampler, annually. The final item of normal operating costs reflects the postage charge for mailing blocks of samples into a central laboratory facility. This cost is estimated at $1 per sample or $61 per year.

The proper maintenance of an SO_2 bubbler would require an average of forty hours of a technician's time annually. At a burdened rate of $9 per hour this would average $360 per year. The estimated annual cost of replacement parts is $200. Therefore, the total projected annual expenditure on maintenance and repair for each SO_2 bubbler is $560.

Finally, supervision and quality control are expected to cost $720 apiece annually. In aggregating overall cost categories, total annual costs of SO_2 bubbler operation are projected at $2887 in Table 2-3.

2.1.5 SO_2 Continuous Sampler

Though the number of continuous instruments required of the states (see Table 1-1) is much smaller than that for mechanized instruments, the cost of continuous instruments is markedly higher. The initial installed cost of an SO_2 continuous sampler is estimated at $8350. (Table 2-4). This includes an estimated $4200 for a flame photometric total sulfur analyzer, $1000 for a strip chart recorder, and $800 for a hydrogen generator. An SO_2 calibration system costs approximately $2250; since it can also be used to calibrate the total oxidant and NO_2 continuous analyzers and since it can be moved, though clumsily, from one site to another, the cost of the calibration system was annualized by assuming each system is used to calibrate an average of five analyzers, i.e. one-fifth of the capital cost is amortized over five years.

The estimated annual cost of electricity and materials for the operation of an SO_2 continuous sampler is $150. The personnel costs for calibration and daily operational checks are estimated under the assumption that each SO_2 continuous instrument will require at least one hour per working day from a technician trained to complete these

Table 2-3. SO_2 GAS BUBBLER SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital costs*		
Gas sampler with shelter and timer.	$ 400.	$ 80.
Sample tubes, orifice tubes, demistor, filter, and orifices.	183.	36.
Installation	50.	10.
II. Normal operating costs		
Electric power		40.
Reagents		50.
Sampling (20 minutes per sample, 61 samples per year, $9 per hour)		183.
Sample analysis (30 minutes per sample, 61 samples per year, $14 per hour)		427.
Sample block mailing costs (61 samples per year, $1 per sample)		61.
III. Maintenance and repair		
Equipment maintenance (40 hours per year, $9 per hour)		360.
Replacement parts		200.
IV. Supervision and quality control		
Supervise, review, validate and report data (36 hours per year, $20 per hour)		720.
Quality control (40 hours per year, $18 per hour)		720.
Totals	$ 633.	$ 2,887.

*Capital costs are amortized over a five-year period in equal installments.

Source: Research Triangle Institute.

Table 2-4. SO_2 CONTINUOUS SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital cost*		
Flame photometric total sulfur analyzer	$ 4,200.	$ 840.
Strip chart recorder	1,000.	200.
Hydrogen generator	800.	160.
Calibration system†	2,250.	90.
Installation	100.	20.
II. Normal operating costs		
Electric power		50.
Recorder paper		100.
Calibration and daily operational checks (5 hours per week, 260 hours per year, $9 per hour)		2,340.
Data reduction (100 hours per year, $8 per hour)		800.
III. Maintenance and repair		
Maintenance (52 hours per year, $10 per hour)		520.
Replacement parts		400.
IV. Supervision and quality control		
Supervise, review, validate, and report data (72 hours per year, $20 per hour)		1,440.
Quality control (35.5 hours per year, $18 per hour)		640.
Totals	$ 8,350.	$ 7,600.

*Capital costs are amortized over a five-year period in equal installments.

†Amortization assumes that one calibration system is used for every five analyzers.

Source: Research Triangle Institute.

tasks. At an estimated $9 per hour, these costs are substantial: $2340 per year. The time required to read and transcribe strip chart data is estimated at 100 hours per year at a burdened rate of $8 per hour. Together the annual personnel costs of normal SO_2 continuous analyzer operation are estimated at $3140.

Maintenance, repair, and replacement parts are projected to cost $920 annually. The hourly burdened rate for maintenance is estimated at $10/hour, slightly higher on average than for mechanized samplers, because it is assumed that a junior engineer is required for the somewhat more complex maintenance work on continuous instruments. This procedure is also followed for the remaining continuous instruments discussed in this report. Supervision and the quality control program are estimated to cost $2080 annually. In total, the annual costs of SO_2 continuous analyzer operation are projected in Table 2-4 at $7600.

2.1.6 CO Continuous Sampler

The CO analyzer and associated capital equipment requirements are estimated at $5100 in Table 2-5. The major cost element is the analyzer itself which costs about $3400. Other capital inputs required are the strip chart recorder at $1000 and accessories, calibration gases, installation, etc. at $700.

Electricity and supplies for CO sampler operation cost about $200 annually. Calibration and operational checks are not as demanding as those for some other continuous instruments; together they are estimated to require three hours per week or $1248 annually. Data reduction time costs are projected at 100 hours per year at an $8 per hour burdened rate, or $800 per year.

The maintenance and quality control time requirements for the CO analyzer are substantially higher than for the SO_2 continuous instrument. Together they are projected at $1000 and $1280 per year, respectively, resulting in aggregate projected costs of $2280. The other cost items in categories III and IV project expenditures on replacement parts and supervision at $300 and $1340, respectively.

2.1.7 Continuous Ozone Sampler

The Bendix 8002 chemiluminescent ozone meter costs about $4200. The costs of accessories, including an ethylene regulator and filters, is $75. Other capital requirements, i.e., for the strip chart recorder, calibration system, and installation, are identical to those for the SO_2

Table 2-5. CO CONTINUOUS SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital costs*		
Analyzer	$ 3,400.	$ 680.
Recorder	1,000.	200.
Accessories	100.	20.
Calibration gases, regulators	500.	100.
Installation	100.	20.
II. Normal operating costs		
Electric power		50.
Recorder paper		100.
Supplies		50.
Calibration and operational checks (3 hours per week, $8 per hour)		1,248.
Data reduction (100 hours per year, $8 per hour)		800.
III. Maintenance and repair		
Maintenance (100 hours per year, $10 per hour)		1,000.
Replacement parts		300.
IV. Supervision and quality control		
Supervise, review, validate, and report data (72 hours per year, $20 per hour)		1,440
Quality control (71 hours per year, $18 per hour)		1,280.
Totals	$ 5,100.	$ 7,288.

*Capital costs are amortized over a five-year period in equal installments.

Source: Research Triangle Institute.

continuous sampler. Table 2-6 reports the total capital requirements of $7625 for the O_3 sampler.

Other annual costs reported in Table 2-6 include $250 for electricity and supplies, and $2205 in personnel costs for calibration, operational checks, and data reduction. Maintenance, repair, supervision, and quality control are expected to cost about $3480 annually. The total annual costs of O_x sampler operation are estimated at $7100.

2.1.8 NO_2 Gas Bubbler Sampler

The only differences in the projected annual costs of the NO_2 and SO_2 bubbler samplers result from the smaller number of required NO_2 samples. The cost items affected are the capital outlay for sample tubes etc. and the variable cost items in cost category II in Table 2-7. Overall annual costs are estimated at $2508.

2.1.9 NO_2 Continuous Sampler

The NO_2 continuous sampler is not presently required of any state air quality monitoring networks. However, since several states have proposed to use this instrument its costs were also estimated and are reported in Table 2-8. It is the most expensive of all the instruments reviewed in this study. Its total installed cost, including the calibration system, is $9750. The main component of capital cost is the analyzer itself which costs about $6000. Other annual cost items are based on the cost and time parameters indicated in Table 2-8. Total annual costs are projected to be $8510 per instrument.

2.2 Other Air Quality Monitoring Network Costs

Costs not directly associated with the purchase, operation, and maintenance of air quality monitoring instrumentation consist of non-recurring start-up costs in addition to travel costs to remote sites, equipment replacement costs, and data processing costs. The non-recurring costs include expenditures for instrument housing, for system specification and engineering, for documentation, and for personnel training.

2.2.1 Instrument Housing

Though many shelter types are available for housing air quality monitoring instruments, the approach of this study was to assume that, where new equipment housing is necessary, the states would install structures of a semipermanent type. Based on its previous work,

Table 2-6. CONTINUOUS OZONE SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital Costs*		
Chemiluminescent ozone meter or equivalent	$ 4,200.	$ 840.
Recorder	1,000.	200.
Accessories (ethylene regulator, filters)	75.	15.
Calibration system†	2,250.	90.
Installation	100.	20.
II. Normal operating costs		
Electric power		50.
Recorder paper		100.
Miscellaneous supplies		100.
Calibration and operational checks (3 hours per week, $9 per hour)		1,405.
Data reduction (100 hours per year, $8 per hour)		800.
III. Maintenance and repair		
Maintenance (100 hours per year, $10 per hour)		1,000.
Replacement parts		400.
IV. Supervision and quality control		
Supervise, review, validate, and report data (72 hours per year, $20 per hour)		1,440.
Quality control (35.5 hours per year, $18 per hour)		640.
Totals	$ 7,625.	$ 7,100.

*Capital costs are amortized over a five-year period in equal installments.

†Amortization assumes that one calibration system is used for every five analyzers.

Source: Research Triangle Institute.

Table 2-7. NO_2 GAS BUBBLER SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital cost*		
Gas sampler with shelter and timer	$ 400.	$ 80.
Sample tubes, orifice tubes, demister, filter, and orifices	90.	18.
Installation	50.	10.
II. Normal operating costs		
Electric power		40.
Reagents		30.
Sampling (20 minutes per sample, 30 samples per year, $9 per hour)		90.
Sample analysis (30 minutes per sample, 30 samples per year, $14 per hour)		210.
Sample block mailing costs (30 samples per year, $1 per sample)		30.
III. Maintenance and repair		
Equipment maintenance (40 hours per year, $9 per hour)		360.
Replacement parts		200.
IV. Supervision and quality control		
Supervise, review, validate, and report data (36 hours per year, $20 per hour)		720.
Quality control (40 hours per year, $18 per hour)		720.
Totals	$ 540.	$ 2,508.

*Capital costs are amortized over a five-year period in equal installments.

Source: Research Triangle Institute.

Table 2-8. NO_2 CONTINUOUS SAMPLER--
PURCHASE, OPERATING, AND MAINTENANCE COSTS

	Investment	Annual
I. Capital costs*		
Chemiluminescent analyzer	$ 6,000.	$ 1,200.
Strip chart recorder	1,000.	200.
Accessories		
Stainless steel regulator	300.	60.
NO_2 tank	100.	20.
Installation	100.	20.
Calibration system†	2,250.	90.
II. Normal operating costs		
Electric power		50.
Recorder paper		100.
Supplies		150.
Calibration and daily operational checks (200 hours per year, $9 per hour)		1,800.
Data reduction (100 hours per year, $8 per hour)		800.
III. Maintenance and repair		
Maintenance (100 hours per year, $10 per hour)		1,000.
Replacement parts		300.
IV. Supervision and quality control		
Supervise, review, validate, and report data (72 hours per year, $20 per hour)		1,440.
Quality control (71 hours per year, $18 per hour)		1,280.
Totals	$ 9,750.	$ 8,510.

*Capital costs are amortized over a five-year period in equal installments.

†Amortization assumes that one calibration system is used for every five analyzers.

Source: Research Triangle Institute.

RTI regarded the prefabricated, aluminum-sided building as the most desireable after consideration of size, environmental control, cost, and durability requirements.* These buildings consist of a corrugated aluminum shell with a welded steel framework. They are insulated and contain all-seasons air conditioning units. Three size options seemed appropriate to satisfy the needs of the states in setting up new monitoring sites. They were: ten by twenty-two feet, eight by twelve feet, and three by four feet. The estimated purchase costs for these shelters were $5000, $2500, and $350, respectively.

As discussed in the next chapter, the number of new air quality monitoring sites resulting from both the implementation of the federal air quality monitoring requirements and from the implementation of the SIPs were projected. Also, the number and type of instruments to be located at each site was projected. By using this information the necessary number of new shelters was projected.

First, it was assumed that all existing instruments were adequately housed and, therefore, that the states would incur no additional costs to house that equipment. Secondly, it was assumed that the states will use sites of opportunity whenever feasible. (A site of opportunity is defined as any municipal building or private property where instruments are sited without additional expenditures for shelters, e.g., a fire or police station.) A site of opportunity was regarded as feasible if the projected site included only one sampler, unless the single instrument was an SO_2, CO, or NO_2 continuous sampler, all of which require more strictly controlled temperatures and humidity for proper operation. A site of opportunity was also assumed adequate if the projected site contained only a high volume and a tape particulate sampler. All other projected equipment configurations were assumed to require a separate semipermanent structure of the type just discussed. The appropriate structure size was simply based on space requirements, e.g., a full

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*C. E. Decker, et al, Program for Upgrading the NO_2 Instrumentation Employed in the 1972 Chattanooga NO_2 Exposure Study, Final Report on Project No. CAPM-10-71 to the Coordinating Research Council, Inc. Research Triangle Park, N.C.: Research Triangle Institute, 1973, pp. 9-10.

complement of samplers would require a ten by twenty-two foot structure whereas an NO_2 and an SO_2 bubbler could be accomodated by a three by four foot shelter.

2.2.2 Data Processing Costs

Since the federal requirements do not include automatic or telemetered air quality monitoring systems (see Chapter 4), the relevant data processing costs were assumed to include routine calculations and keypunching and verification of computer cards. It was assumed that, on the average, data from each sampler in the air quality monitoring network would require about ten computer cards per day. Keypunching and verification costs were estimated at seven cents per card and the personnel costs for routine calculations were approximated at $45 per sampler per year. Consequently, aggregate annual data processing costs were estimated at $300 (365 x 10 x .07 + 45) per sampler per year.

2.2.3 Travel Costs

Travel costs consist of two items: (1) the time cost of the technician who commutes to and from the air quality monitoring site and (2) the cost of vehicle operation. It was assumed here that the average distance between the monitoring site and the central facility is eight miles and that the average time required for a round trip is thirty minutes. In assuming that the burdened wage rate for the commuting technician is $9 per hour, the personnel travel costs were estimated at $4.50 ($9 x 1/2 hour). Vehicle related costs were estimated at twelve cents per mile or $1.92 per round trip (16 x .12). Aggregate travel costs were therefore estimated at $6.42 ($4.50 + $1.92) per round trip to a monitoring site.

2.2.4 System Setup Costs

Although most states currently have at least partial air quality monitoring networks they will clearly incur additional costs for a variety of fixed items associated with enlarging or completing the networks. These include: system specification preparation and engineering; documentation of system operation and maintenance techniques; and personnel training costs.

System specification costs include the expenses of preparing grant applications, of designing the network, of preparing the requests for

proposals on instrumentation contracts, of evaluating those proposals, and of supervising the construction and testing of new instruments. System engineering costs reflect the time requirements to evaluate and select new monitoring sites.

Documentation costs refer to the necessary outlays of time and materials in preparing operation and maintenance manuals for network instrumentation. Finally, training costs include the salary and expenses required to school maintenance and operating technicians in the proper techniques of sample analysis, instrument maintenance, strip chart reading etc.

The method of estimating these costs was primarily based on previous work by the MITRE Corporation.* It was assumed that these costs will be incurred only once at the initiation of the system. Following MITRE's technique it was estimated that documentation costs will be approximately five percent of new hardware costs. System engineering costs were estimated at 16 hours at each new site for both a senior engineer ($18 per hour) and a technician ($9 per hour). System specification costs and training costs were projected at $9000 per fifty new instruments.

2.2.5 Equipment Replacement Costs

After reviewing the MITRE cost model and the work reported by Kovalick, in addition to reflecting on RTI's experience in air monitoring equipment operation,† it appeared reasonable to assign five years as the average replacement time for air quality monitoring instrumentation. Therefore, the number of each type of instrument to be replaced by mid-1974 was estimated as twenty percent of the number of existing instruments that are needed to meet either the federal requirements or the requirements of the proposals in the state implementation plans. These estimated numbers were then multiplied by the approximate cost of each instrument (reported in Tables 2-1 through 2-8) and summed to

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*See W. H. Keenan, et al. (1969).

†See W. H. Keenan, et al., op. cit. and Walter W. Kovalick, Jr. "The Demand for Air Monitoring Instruments," Pollution Engineering, V, No. 9 (September, 1973), p. 39.

derive a final estimate of the cost of replacing currently existing instruments to meet the hardware requirements for the monitoring systems that are expected to be operational by mid-1974. The costs of replacing equipment in future years are accounted for in the annualized capital charge reported in Tables 2-1 through 2-8.

2.3 Summary

This chapter summarized the cost factors that were employed in the computation of projected aggregate expenditures to upgrade currently existing air quality monitoring systems to satisfy federal requirements. These factors included individual instrument purchases and installation expenditures as well as operating, maintenance, supervision, and quality control costs. Separate cost factors were projected for instrument shelters, for data processing, for travel to remote sites, for system design, documentation and training and finally for the expected replacement of existing instruments.

CHAPTER 3: AGGREGATE AIR QUALITY MONITORING COST ESTIMATES

This chapter presents air quality monitoring cost estimates that are based on the cost factors developed in Chapter 2. Section 3.1 discusses and presents in a tabular format some of the relevant data on numbers of instruments and air quality monitoring sites that were used in projecting the demand for new instruments and sites. Section 3.2 gives the projected new investment and expected annual operating costs associated with individual air quality monitoring instruments. Finally, Section 3.3 summarizes the cost data of Section 3.2 and incorporates additional cost estimates for other items specific to the number of new monitoring sites that were projected. Those items included instrument housing costs, initial personnel costs, and travel costs.

3.1 Monitoring Instruments and Sites, by State

3.1.1 Total Required, Proposed, and Existing Instruments

To develop projections of the number of air quality monitoring instruments of each type that will be in operation by mid-1974, it was first necessary to refer to air sampling instrument inventories that were reported in the SIP's. Then, since this study set out to project instrumentation needs under both the requirements of the federal promulgations (Appendix A) and the requirements of state proposed monitoring networks, it was necessary to determine the number of existing instruments that would be employed given each of these two sets of demand assumptions (referred to in Table 3-1 and hereafter as "required" and "proposed," respectively).

Table 3-1 arrays two sets of data for each state. The left half of the table displays data which are relevant to the federally required network of monitoring instruments; the right half to the state proposed network. For each state, within each of these two groups, three tabular headings are indicated: projected, existing, and total. The "total" entries refer to the number of each type of instrument that would be necessary to meet the stipulations of either the required or of the state proposed network, according to whether one refers to the left or to the right hand portion of the table. The entry labelled "existing" indicates the number of currently operating instruments of each type (as reported in the SIP's) that are needed to meet the relevant stipulations as reported in the "total" entries. Finally, the "projected" entries are simply the difference between

the "total" and the "existing" entries. The numbers of projected instruments are the estimates of the number of new instruments of each type that must be purchased to meet the relevant requirements.

3.1.2 Assumed Site Configurations

Several of the cost elements mentioned in Section 2.2 required an estimate of the number of sites and of the configuration of air quality monitoring equipment at each site to obtain appropriate aggregate cost estimates. These data were projected in the following manner. First, it was assumed that all existing instruments are adequately housed and that they are combined at each site so as to minimize the number of sites without having duplicate instruments at each location. That number is reported in the column headed "Total Sites" in Table 3-1. For example, in Alabama under the federal requirements, it is estimated that 37 different locations are needed to accommodate existing instruments.

For projected new instruments, essentially the same procedure was applied by using the data reported in the entry labelled "projected." Again an Alabama example, it was expected that 13 new sites would be necessary to accommodate new instruments dictated by the federal requirements.

For two reasons the U.S. totals at the end of Table 3-1 are not fully comparable to the data reported in Table 1-1. First, the horizontal entries labelled "existing" in Table 3-1 report only the number of currently operating instruments that are needed to meet the specifications of either the federal requirements or of the state proposed air monitoring plans. In conjunction with the fact that several states report larger inventories of certain instruments than are needed under either the federally required or the state proposed plans, this reporting method causes part of the difference between the aggregate numbers of "existing" instruments under the state proposed plans and the number of existing instruments reported in Table 1-1. A second source of the difference was the use, in this report, of the instrument inventories gathered by Kovalick (1973b) for the three states--Florida, Louisiana, North Carolina--whose implementation plans failed to report instrument inventories. This technique was likely to have estimated instrument inventories which differed from those assumed by EPA in providing the tabulations of Table 1-1.

TABLE 3-1. NUMBER OF EXISTING AND PROJECTED AIR QUALITY MONITORING INSTRUMENTS AND SITES AS REQUIRED OF AND PROPOSED BY INDIVIDUAL STATES[a]

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
Alabama																			
Projected	0	11	13	3	2	3	0	32	13	0	11	14	4	2	3	0	0	34	14
Existing	37	5	1	0	1	1	0	45	37	38	5	1	0	1	1	0	0	46	38
Total	37	16	14	3	3	4	0	77	50	38	16	15	4	3	4	0	0	80	52
Alaska																			
Projected	5	2	5	1	1	0	0	14	5	22	2	5	1	1	0	1	0	32	22
Existing	6	0	1	0	0	0	0	7	6	6	0	1	0	0	0	1	0	8	6
Total	11	2	6	1	1	0	0	21	11	28	2	6	1	1	0	2	0	40	28
Arizona																			
Projected	0	1	9	0	1	1	7	19	9	2	4	1	5	2	1	8	0	23	8
Existing	16	7	4	5	2	2	4	40	16	33	7	4	7	2	2	4	1	60	33
Total	16	8	13	5	3	3	11	59	25	35	11	5	12	4	3	12	1	83	41
Arkansas																			
Projected	0	2	3	0	0	0	1	6	3	13	5	5	0	0	0	1	0	24	13
Existing	9	0	1	0	0	0	0	10	9	16	0	1	0	0	0	0	0	17	16
Total	9	2	4	0	0	0	1	16	12	29	5	6	0	0	0	1	0	41	29
California																			
Projected	0	22	0	0	0	0	30	52	30	32	53	0	3	13	13	12	4	130	53
Existing	66	0	15	2	29	32	0	144	66	70	0	17	20	44	68	0	50	269	70
Total	66	22	15	2	29	32	30	196	96	102	53	17	23	57	81	12	54	399	123
Colorado																			
Projected	0	3	7	0	2	2	0	14	7	11	13	6	5	5	5	0	5	50	13
Existing	27	4	1	0	1	1	0	34	27	55	4	1	2	1	1	0	1	65	55
Total	27	7	8	0	3	3	0	48	34	66	17	7	7	6	6	0	6	115	68
Connecticut																			
Projected	0	0	7	0	3	2	10	22	10	7	0	6	5	4	4	22	0	48	22
Existing	19	10	5	5	2	3	0	44	19	60	39	5	19	2	3	0	2	130	60
Total	19	10	12	5	5	5	10	66	29	67	39	11	24	6	7	22	2	178	82
Delaware																			
Projected	0	0	0	0	0	0	0	0	0	6	6	6	6	0	0	6	0	30	6
Existing	3	1	2	1	1	1	1	10	10	14	14	10	14	4	4	14	4	78	14
Total	3	1	2	1	1	1	1	10	10	20	20	16	20	4	4	20	4	108	20
District of Columbia																			
Projected	0	0	3	0	0	0	3	6	3	3	3	0	3	3	1	0	2	15	3
Existing	4	2	0	1	1	1	0	9	4	7	7	0	3	2	1	0	2	22	7
Total	4	2	3	1	1	1	3	15	7	10	10	0	6	5	2	0	4	37	10

[a] Instrument inventories were made available by the EPA. The number of existing instruments refers only to those needed under either the federal requirements or the state proposals.

[b] Instrument inventories in this state unclear in implementation plans. Inventory data gathered by Kovalick (1973b) was employed.

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
Florida[b]																			
Projected	0	8	0	0	0	0	7	15	8	0	7	0	1	0	0	7	0	15	7
Existing	30	6	16	5	0	4	13	74	30	30	6	16	5	0	3	13	0	73	30
Total	30	14	16	5	0	4	20	89	38	30	13	16	6	0	3	20	0	88	37
Georgia																			
Projected	3	12	15	6	0	0	9	45	15	16	18	18	7	0	0	10	0	69	18
Existing	40	5	11	4	0	1	6	67	40	40	5	11	4	3	1	6	1	71	40
Total	43	17	26	10	0	1	15	112	55	56	23	29	11	3	1	16	1	140	58
Hawaii																			
Projected	0	0	0	0	0	0	0	0	0	5	2	3	0	1	1	4	0	16	5
Existing	3	1	1	0	0	0	0	5	3	7	1	5	1	1	1	5	0	21	7
Total	3	1	1	0	0	0	0	5	3	12	3	8	1	2	2	9	0	37	12
Idaho																			
Projected	0	3	6	0	0	0	0	9	6	8	4	8	0	0	0	0	0	20	8
Existing	15	0	0	1	0	0	0	16	15	27	0	0	3	0	0	0	0	30	27
Total	15	3	6	1	0	0	0	25	21	35	4	8	3	0	0	0	0	50	35
Illinois																			
Projected	0	0	8	0	1	4	12	25	12	9	12	21	6	7	6	13	1	75	21
Existing	56	19	29	16	9	6	0	135	56	116	22	29	26	9	6	3	10	221	116
Total	56	19	37	16	10	10	12	160	68	125	34	50	32	16	12	16	11	296	137
Indiana																			
Projected	0	0	0	0	4	4	0	8	4	30	19	46	14	7	7	43	0	166	46
Existing	45	15	28	10	0	0	13	111	45	94	24	43	18	0	0	37	0	216	94
Total	45	15	28	10	4	4	13	119	49	124	43	89	32	7	7	80	0	382	140
Iowa																			
Projected	2	9	8	0	0	1	0	20	9	13	11	9	2	0	1	2	0	38	13
Existing	31	1	4	1	0	1	2	40	31	31	1	4	1	1	1	2	0	41	31
Total	33	10	12	1	0	2	2	60	40	44	12	13	3	1	2	4	0	79	44
Kansas																			
Projected	0	7	0	0	0	2	0	9	7	25	9	28	2	2	4	32	1	103	32
Existing	34	1	6	0	1	1	0	43	34	34	1	8	0	3	1	3	0	50	34
Total	34	8	6	0	1	3	0	52	41	59	10	36	2	5	5	35	1	153	66
Kentucky																			
Projected	0	0	0	0	0	0	0	0	0	87	15	90	11	11	9	109	1	333	109
Existing	30	11	14	3	0	3	10	71	30	78	17	60	12	3	3	51	2	226	78
Total	30	11	14	3	0	3	10	71	30	165	32	150	23	14	12	160	3	559	187

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
Louisiana[b]																			
Projected	0	0	5	0	0	0	0	5	5	4	1	8	1	0	1	0	0	15	8
Existing	5	2	5	5	0	5	0	22	6	5	2	5	5	0	5	0	0	22	5
Total	5	2	10	5	0	5	0	27	11	9	3	13	6	0	6	0	0	37	13
Maine																			
Projected	7	2	5	1	0	0	0	15	7	16	3	17	1	0	0	0	0	37	17
Existing	6	1	5	2	0	0	0	14	6	6	1	5	2	0	0	0	0	14	6
Total	13	3	10	3	0	0	0	29	13	22	4	22	3	0	0	0	0	51	23
Maryland																			
Projected	0	0	0	0	0	0	0	0	0	12	9	14	9	8	6	14	0	72	14
Existing	31	14	21	8	6	6	14	100	31	62	16	24	17	12	13	20	4	168	62
Total	31	14	21	8	6	6	14	100	31	74	25	38	26	20	19	34	4	240	76
Massachusetts																			
Projected	0	4	0	1	3	3	0	11	4	17	9	20	14	8	9	16	7	100	20
Existing	34	12	21	8	3	3	16	97	34	46	12	46	8	3	3	46	0	164	46
Total	34	16	21	9	6	6	16	108	38	63	21	66	22	11	12	62	7	264	66
Michigan																			
Projected	0	11	12	0	0	0	15	38	15	47	28	30	11	10	5	30	4	165	47
Existing	29	1	6	8	0	0	6	50	29	80	1	6	16	0	0	6	1	110	80
Total	29	12	18	8	0	0	21	88	44	127	29	36	27	10	5	36	5	275	127
Minnesota																			
Projected	0	0	1	0	0	0	1	2	1	0	1	5	5	0	2	1	0	14	5
Existing	27	12	15	6	4	0	9	73	27	68	22	15	7	4	3	9	3	131	68
Total	27	12	16	6	4	0	10	75	28	68	23	20	12	4	5	10	3	145	73
Mississippi																			
Projected	0	6	6	2	0	2	0	16	6	12	6	14	4	0	3	1	0	40	14
Existing	11	0	1	0	0	0	0	12	11	17	0	1	0	0	0	0	0	18	17
Total	11	6	7	2	0	2	0	28	17	29	6	15	4	0	3	1	0	58	31
Missouri																			
Projected	0	0	5	0	0	0	4	9	5	7	5	0	4	3	4	1	3	27	7
Existing	30	14	6	4	6	6	3	69	30	68	15	6	7	10	9	3	9	127	68
Total	30	14	11	4	6	6	7	78	35	75	20	6	11	13	13	4	12	154	75
Montana																			
Projected	6	2	9	1	0	0	0	18	9	7	2	9	2	0	0	0	0	20	9
Existing	7	1	2	2	0	0	0	12	7	7	1	2	2	0	0	0	0	12	7
Total	13	3	11	3	0	0	0	30	16	14	3	11	4	0	0	0	0	32	16

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
Nebraska																			
Projected	0	0	5	1	0	0	5	11	5	0	1	5	1	0	0	6	0	13	6
Existing	12	3	1	0	0	0	1	17	12	29	3	1	0	0	0	1	0	34	29
Total	12	3	6	1	0	0	6	28	17	29	4	6	1	0	0	7	0	47	35
Nevada																			
Projected	0	1	0	2	1	0	0	4	2	0	2	0	2	1	1	0	0	6	2
Existing	13	2	6	0	1	2	5	29	13	34	2	6	0	1	2	5	3	53	34
Total	13	3	6	2	2	2	5	33	15	34	4	6	2	2	3	5	3	59	36
New Hampshire																			
Projected	0	2	3	2	0	0	0	7	3	7	6	9	4	2	1	12	0	41	12
Existing	8	0	4	0	0	0	0	12	8	25	0	4	0	0	0	1	0	30	25
Total	8	2	7	2	0	0	0	19	11	32	6	13	4	2	1	13	0	71	37
New Jersey																			
Projected	0	0	13	0	0	3	7	23	13	0	0	5	1	0	3	8	0	17	8
Existing	19	5	0	7	8	4	0	43	19	50	22	0	21	22	4	0	0	119	50
Total	19	5	13	7	8	7	7	66	32	50	22	5	22	22	7	8	0	136	58
New Mexico																			
Projected	0	1	2	0	0	1	0	4	2	10	7	16	2	1	1	12	0	49	16
Existing	16	2	6	1	1	2	0	28	16	42	2	6	3	2	2	6	0	63	42
Total	16	3	8	1	1	3	0	32	18	52	9	22	5	3	3	18	0	112	58
New York																			
Projected	0	0	23	0	0	7	19	49	23	106	10	5	34	7	14	21	0	197	106
Existing	72	25	16	19	13	9	7	161	72	230	47	6	45	22	9	7	0	366	230
Total	72	25	39	19	13	16	26	210	95	336	57	11	79	29	23	28	0	563	336
North Carolina[b]																			
Projected	0	0	0	0	0	0	0	0	0	111	28	121	0	4	3	0	0	267	121
Existing	54	17	10	1	0	2	0	84	54	54	17	10	0	0	2	0	0	83	54
Total	54	17	10	1	0	2	0	84	54	165	45	131	0	4	5	0	0	350	175
North Dakota																			
Projected	0	2	1	0	0	0	0	3	2	0	2	1	0	0	0	1	0	4	2
Existing	6	0	1	0	0	0	0	7	6	15	0	1	0	0	0	0	0	16	15
Total	6	2	2	0	0	0	0	10	8	15	2	2	0	0	0	1	0	20	17
Ohio																			
Projected	0	20	15	0	0	0	0	35	20	53	29	59	0	0	0	0	0	141	59
Existing	78	12	25	0	0	0	0	115	78	202	12	35	24	0	0	0	0	273	202
Total	78	32	40	0	0	0	0	150	98	255	41	94	24	0	0	0	0	414	261

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instru-	Total	PM		SO_2		CO	O_x	NO_2		Total Instru-	Total
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	ments	Sites	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	ments	Sites
Oklahoma																			
Projected	0	4	0	0	0	2	0	6	4	19	7	7	3	1	2	0	0	39	19
Existing	24	3	7	0	0	2	0	36	24	79	3	8	0	3	2	0	0	95	79
Total	24	7	7	0	0	4	0	42	28	98	10	15	3	4	4	0	0	134	98
Oregon																			
Projected	0	4	1	0	0	1	0	6	4	0	4	2	0	1	1	4	0	12	4
Existing	20	5	5	1	3	2	0	36	20	27	5	5	1	3	2	0	0	43	27
Total	20	9	6	1	3	3	0	42	24	27	9	7	1	4	3	4	0	55	31
Pennsylvania																			
Projected	0	18	28	0	0	4	45	95	45	35	45	0	42	38	37	0	53	250	53
Existing	68	15	0	14	11	7	0	115	68	81	15	0	17	12	7	0	7	139	81
Total	68	33	28	14	11	11	45	210	113	116	60	0	59	50	44	0	60	389	134
Puerto Rico																			
Projected	0	1	2	1	0	0	0	4	2	18	7	2	19	1	0	16	0	63	19
Existing	3	0	1	0	0	0	0	4	3	4	0	1	0	0	0	3	0	8	4
Total	3	1	3	1	0	0	0	8	5	22	7	3	19	1	0	19	0	71	23
Rhode Island																			
Projected	0	4	0	2	0	0	0	6	4	7	4	3	4	4	4	7	0	33	7
Existing	7	0	5	0	0	0	6	18	7	18	0	18	0	0	0	18	0	54	25
Total	7	4	5	2	0	0	6	24	11	25	4	21	4	4	4	25	0	87	32
South Carolina																			
Projected	4	1	4	0	0	0	0	9	4	4	1	4	0	0	0	0	0	9	4
Existing	2	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	2	2
Total	6	1	4	0	0	0	0	11	6	6	1	4	0	0	0	0	0	11	6
South Dakota																			
Projected	4	1	4	0	0	0	0	9	4	4	1	4	0	0	0	0	0	9	4
Existing	2	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	2	2
Total	6	1	4	0	0	0	0	11	6	6	1	4	0	0	0	0	0	11	6
Tennessee																			
Projected	0	12	9	2	0	1	0	24	12	4	12	40	4	1	3	20	2	86	40
Existing	39	4	5	2	0	4	11	65	39	92	4	5	2	4	4	16	0	127	92
Total	39	16	14	4	0	5	11	89	51	96	16	45	6	5	7	36	2	213	132
Texas																			
Projected	0	17	0	12	1	19	0	49	19	81	22	120	61	79	81	0	79	523	120
Existing	52	3	37	0	0	0	0	92	52	140	3	51	0	0	0	0	0	194	140
Total	52	20	37	12	1	19	0	141	71	221	25	171	61	79	81	0	79	717	260

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
Utah																			
Projected	3	0	5	0	0	0	6	14	6	11	0	11	1	1	1	11	1	37	11
Existing	8	3	4	2	2	2	4	25	8	8	5	4	5	4	4	4	5	39	8
Total	11	3	9	2	2	2	10	39	14	19	5	15	6	5	5	15	6	76	19
Vermont																			
Projected	0	0	3	0	0	0	0	3	3	3	1	2	4	0	0	0	0	10	4
Existing	4	1	1	1	0	0	0	7	4	7	1	1	2	1	1	0	1	14	7
Total	4	1	4	1	0	0	0	10	7	10	2	3	6	1	1	0	1	24	11
Virginia																			
Projected	0	9	0	3	0	3	1	16	9	35	12	24	7	4	3	18	0	103	35
Existing	55	11	17	2	2	4	20	111	55	73	11	23	2	3	4	20	2	138	73
Total	55	20	17	5	2	7	21	127	64	108	23	47	9	7	7	38	2	241	108
Washington																			
Projected	0	0	11	0	0	0	10	21	11	1	1	4	1	0	0	10	0	17	10
Existing	31	14	0	3	7	5	0	60	31	71	18	0	20	9	7	0	3	128	71
Total	31	14	11	3	7	5	10	81	42	72	19	4	21	9	7	10	3	145	81
West Virginia																			
Projected	0	0	0	2	0	0	0	2	2	3	2	8	2	0	0	0	0	15	8
Existing	24	5	10	0	0	0	0	39	24	34	22	13	0	1	3	0	0	73	34
Total	24	5	10	2	0	0	0	41	26	37	24	21	2	1	3	0	0	88	42
Wisconsin																			
Projected	0	7	0	0	0	0	3	10	7	3	9	8	5	8	5	1	5	44	9
Existing	24	3	8	1	0	4	7	47	24	71	3	22	4	1	6	7	1	115	71
Total	24	10	8	1	0	4	10	57	31	74	12	30	9	9	11	8	6	159	80
Wyoming																			
Projected	1	2	2	0	0	0	0	5	2	4	2	2	0	0	0	0	0	8	4
Existing	6	0	1	0	0	0	0	7	6	6	0	1	0	0	0	0	0	7	6
Total	7	2	3	0	0	0	0	12	8	10	2	3	0	0	0	0	0	15	10
American Samoa																			
Projected	1	0	1	0	0	0	0	2	1	1	0	1	0	0	0	0	0	2	1
Existing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	0	1	0	0	0	0	2	1	1	0	1	0	0	0	0	0	2	1
Guam																			
Projected	1	0	3	1	0	0	0	5	3	2	1	3	1	0	0	0	0	7	3
Existing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	0	3	1	0	0	0	5	3	2	1	3	1	0	0	0	0	7	3

Table 3-1 (continued)

	Required									Proposed									
	PM		SO_2		CO	O_x	NO_2	Total Instruments	Total Sites	PM		SO_2		CO	O_x	NO_2		Total Instruments	Total Sites
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb			HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont		
U.S. Virgin Is.																			
Projected	0	0	1	1	0	0	0	2	1	0	0	1	1	0	0	0	0	2	1
Existing	3	1	2	0	0	0	0	6	3	6	1	2	0	0	0	0	0	9	6
Total	3	1	3	1	0	0	0	8	4	6	1	3	1	0	0	0	0	11	7
Total U.S.																			
Projected	37	211	263	44	19	65	195	834	406	933	474	850	325	240	245	480	168	3715	1242
Existing	1301	279	393	151	114	126	158	2522	1285	2517	419	549	345	193	188	311	112	4639	2524
Total	1338	490	656	195	133	191	353	3356	1691	3450	893	1399	670	433	433	791	280	8349	3766

3.2 Instrument Specific Air Monitoring Cost Estimates, by State

This section reports the initial costs of air quality monitoring instruments and their annual operating costs by state for each instrument type. Table 3-2 summarizes these data.

Table 3-2 follows the format of Table 3-1 in distinguishing federal requirements ("required" in the left portion of the table) from the requirements implicit in the state proposals ("proposed" in the right portion of the table). For each state and instrument, there are two categories of cost: total initial investment and total annual cost.

The total initial investment requirement is further subdivided into new investment and replacement investment. The former estimate is simply developed by multiplying the number of projected instruments from Table 3-1 by the relevant investment requirement from Tables 2-1 through 2-8. Following the assumption that the average life of a monitoring instrument is five years, it was assumed that 20 percent of all existing instruments in each state must be replaced by mid-1974. Therefore, the necessary expenditure or replacement investment was estimated as 20 percent of the product of the number of existing instruments from Table 3-1 and the relevant investment requirement from Tables 2-1 through 2-8.

To derive an annualized capital cost, the total number of instruments arrayed in Table 3-1 (under either "required" or "proposed" assumptions) were multiplied by the sum of the "annual" entries in Tables 2-1 through 2-8 that are in cost category I, capital costs. For example, in Alabama under "required" assumptions, 16 tape samplers are needed. That total (16) was multiplied by $205, the sum of the "annual" cost entries in category I of Table 2-2 to yield the annual capital cost of $3280 in Table 3-2.

Finally, the annual variable costs of equipment operation are estimated by multiplying the remaining annual costs, i.e., non-capital related annual costs, by the same total number of instruments arrayed in Table 3-1. Using the same example from Alabama for tape samplers under "required" assumptions, the remaining annual costs are $5154 ($5359 from Table 2-2 less the $205 in annual capital costs). These costs times the total number of required tape samplers yields the annual variable cost, $82,464 ($5154 x 16).

Table 3-2 also presents cost totals for all four cost breakdowns under both "required" and "proposed" assumptions for each state.

Table 3-2. ESTIMATED INITIAL PURCHASE AND ANNUAL OPERATING COSTS OF AIR SAMPLING INSTRUMENTS, BY TYPE

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Alabama																	
New investment	0	11,275	8,229	25,050	10,200	22,875	0	77,629	0	11,275	8,862	33,400	10,200	22,875	0	0	86,612
Replacement investment	3,034	1,025	127	0	1,020	1,525	0	6,731	3,116	1,025	127	0	1,020	1,525	0	0	6,813
Total initial investment	3,034	12,300	8,356	25,050	11,220	24,400	0	84,360	3,116	12,300	8,989	33,400	11,220	24,400	0	0	93,425
Annualized capital cost	2,479	3,280	1,764	3,930	3,060	4,660	0	19,173	2,546	3,280	1,890	5,240	3,060	4,660	0	0	20,676
Annual variable cost	39,479	82,464	38,654	18,870	18,804	24,320	0	222,591	40,546	82,464	41,415	25,160	18,804	24,320	0	0	232,709
Total annual cost	41,958	85,744	40,418	22,800	21,864	28,980	0	241,764	43,092	85,744	43,305	30,400	21,864	28,980	0	0	253,385
Alaska																	
New investment	2,050	2,050	3,165	8,350	5,100	0	0	20,715	9,020	2,050	3,165	8,350	5,100	0	540	0	9,560
Replacement investment	492	0	127	0	0	0	0	619	492	0	127	0	0	0	108	0	727
Total initial investment	2,542	2,050	3,292	8,350	5,100	0	0	21,334	9,512	2,050	3,292	8,350	5,100	0	648	0	10,287
Annualized capital cost	737	410	756	1,310	1,020	0	0	4,233	1,876	410	756	1,310	1,020	0	216	0	5,588
Annual variable cost	11,737	10,308	16,566	6,290	6,268	0	0	51,169	29,876	10,308	16,566	6,290	6,268	0	4,900	0	74,208
Total annual cost	12,474	10,718	17,322	7,600	7,288	0	0	55,402	31,752	10,718	17,322	7,600	7,288	0	5,116	0	79,796
Arizona																	
New investment	0	1,025	5,697	0	5,100	7,625	3,780	23,227	820	4,100	633	41,750	10,200	7,625	4,320	0	69,448
Replacement investment	1,312	1,435	506	8,350	2,040	3,050	432	17,125	2,706	1,435	506	11,690	2,040	3,050	432	390	22,249
Total initial investment	1,312	2,460	6,203	8,350	7,140	10,675	4,112	40,352	3,526	5,535	1,139	53,440	12,240	10,675	4,752	390	91,697
Annualized capital cost	1,072	1,640	1,638	6,550	3,060	3,495	1,188	18,643	2,345	2,255	630	15,720	4,080	3,495	1,296	1,590	31,411
Annual variable cost	17,072	41,232	35,893	31,450	18,804	18,240	26,950	189,641	37,345	56,694	13,805	75,480	25,072	18,240	29,400	6,920	262,956
Total annual cost	18,144	42,872	37,531	38,000	21,864	21,735	28,138	208,284	39,690	58,949	14,435	91,200	29,152	21,735	30,696	8,510	294,367
Arkansas																	
New investment	0	2,050	1,899	0	0	0	540	4,489	5,330	5,125	3,165	0	0	0	540	0	14,160
Replacement investment	738	0	127	0	0	0	0	865	1,312	0	127	0	0	0	0	0	1,439
Total initial investment	738	2,050	2,026	0	0	0	540	5,354	6,642	5,125	3,292	0	0	0	540	0	15,599
Annualized capital cost	603	410	504	0	0	0	108	1,625	1,943	1,025	756	0	0	0	108	0	3,832
Annual variable cost	9,603	10,308	11,044	0	0	0	2,450	33,405	30,943	25,770	16,566	0	0	0	2,450	0	75,729
Total annual cost	10,206	10,718	11,548	0	0	0	2,558	35,030	32,886	26,795	17,322	0	0	0	2,558	0	79,561

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_x	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
California																	
New investment	0	9,020	0	0	0	0	16,200	25,220	13,120	54,325	0	25,050	66,300	99,125	6,480	39,000	303,400
Replacement investment	5,412	0	1,899	3,340	29,580	48,800	0	89,031	5,740	0	2,152	33,400	44,880	103,700	0	97,500	287,372
Total initial investment	5,412	9,020	1,899	3,340	29,580	48,800	16,200	114,251	18,860	54,325	2,152	58,450	111,180	202,825	6,480	136,500	590,772
Annualized capital cost	4,422	4,510	1,890	2,620	29,580	37,280	3,240	83,542	6,834	10,865	2,142	30,130	58,140	94,365	1,296	85,860	289,632
Annual variable cost	70,422	113,388	41,415	12,580	181,772	194,176	73,500	687,253	108,834	273,162	46,937	144,670	357,276	492,480	29,400	339,660	1,792,419
Total annual cost	74,844	117,898	43,305	15,200	211,352	231,456	76,740	770,795	115,668	284,027	49,079	174,800	415,416	586,845	30,696	425,520	2,082,051
Colorado																	
New investment	0	3,075	4,431	0	10,200	15,250	0	32,956	4,510	13,325	3,798	41,750	25,500	38,125	0	48,750	175,758
Replacement investment	2,214	820	127	0	1,020	1,525	0	5,706	4,510	820	127	3,340	1,020	1,525	0	1,950	13,292
Total initial investment	2,214	8,895	4,558	0	11,220	16,775	0	38,662	9,020	14,145	3,925	45,090	26,520	39,650	0	50,700	189,050
Annualized capital cost	1,809	1,435	1,008	0	3,060	3,495	0	10,807	4,422	3,485	882	9,170	6,120	6,990	0	9,540	40,609
Annual variable cost	28,809	36,078	22,088	0	18,804	18,204	0	123,983	70,422	87,618	19,327	44,030	37,608	36,408	0	41,520	336,933
Total annual cost	30,618	37,513	23,096	0	21,864	21,699	0	134,790	74,844	91,103	20,209	53,200	43,728	43,398	0	51,060	377,542
Connecticut																	
New investment	0	0	4,421	0	15,300	15,250	5,400	40,381	2,870	0	3,798	41,750	20,400	30,500	11,880	0	111,198
Replacement investment	1,558	2,050	633	8,350	2,040	4,575	0	19,206	4,920	7,995	633	31,730	2,040	4,575	0	3,900	55,793
Total initial investment	1,558	2,050	5,064	8,350	17,340	19,825	5,400	59,587	7,790	7,995	4,431	73,480	22,440	35,075	11,880	3,900	166,991
Annualized capital cost	1,273	2,050	1,512	6,550	5,100	5,825	1,080	23,390	4,489	7,995	1,386	31,440	6,120	8,155	2,376	3,180	65,141
Annual variable cost	20,273	51,540	33,132	31,450	31,340	3,034	34,500	205,269	71,489	201,006	30,371	150,960	37,608	42,560	53,900	13,840	601,734
Total annual cost	21,546	53,590	34,644	38,000	36,440	8,859	35,580	228,659	75,978	209,001	31,757	182,400	43,728	50,715	56,276	17,020	666,875
Delaware																	
New investment	0	0	0	0	0	0	0	0	2,460	6,150	3,798	50,100	0	0	3,240	0	65,748
Replacement investment	246	205	253	1,670	1,020	1,525	108	5,027	1,148	2,870	1,266	23,380	4,080	6,100	21,350	432	60,626
Total initial investment	246	205	253	1,670	1,020	1,525	108	5,027	3,608	9,020	5,064	73,480	4,080	6,100	24,590	432	126,374
Annualized capital cost	201	205	252	1,310	1,020	1,165	108	4,261	1,340	4,100	2,016	26,200	4,080	4,660	2,160	6,360	50,916
Annual variable cost	3,201	5,154	5,522	6,290	6,268	6,080	2,450	34,965	21,340	103,080	44,176	125,800	25,072	24,320	49,000	27,680	420,468
Total annual cost	3,402	5,359	5,774	7,600	7,288	7,245	2,558	39,226	22,680	107,180	46,192	152,000	29,152	28,980	51,160	34,040	471,384

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
District of Columbia																	
New investment	0	0	1,899	0	0	0	1,620	3,519	1,230	3,075	0	25,050	15,300	7,625	0	19,500	71,780
Replacement investment	328	410	0	1,670	1,020	0	432	3,860	574	1,435	0	5,010	2,040	1,525	0	3,900	14,484
Total initial investment	328	410	1,899	1,670	1,020	0	2,052	7,379	1,804	4,510	0	30,060	17,340	9,150	0	23,400	86,264
Annualized capital cost	268	410	378	1,310	1,020	1,165	324	4,875	670	2,050	0	47,160	5,100	2,330	0	6,360	63,670
Annual variable cost	4,268	10,308	8,283	6,290	6,268	6,080	7,350	48,847	10,670	51,540	0	37,740	31,340	12,160	0	27,680	171,130
Total annual cost	4,536	10,718	8,661	7,600	7,288	7,245	7,674	53,722	11,340	53,590	0	84,900	36,440	14,490	0	34,040	234,800
Florida																	
New investment	0	8,200	0	0	0	0	3,780	11,980	0	7,175	0	8,350	0	0	3,780	0	19,305
Replacement investment	2,460	1,230	2,026	8,350	0	4,080	1,404	19,550	2,460	1,230	2,026	8,350	0	4,575	1,404	0	20,045
Total initial investment	2,460	3,690	2,026	8,350	0	18,145	5,184	31,530	2,460	8,205	2,026	16,700	0	4,575	5,184	0	39,350
Annualized capital cost	2,010	2,870	2,016	6,550	0	4,660	2,160	20,266	2,010	2,665	2,016	7,860	0	3,495	2,160	0	20,206
Annual variable cost	32,010	72,156	44,176	31,450	0	24,320	121,600	325,712	32,010	67,002	44,176	37,740	0	18,240	49,000	0	248,168
Total annual cost	34,020	75,026	46,192	38,000	0	28,980	123,760	345,978	34,020	69,667	46,192	45,600	0	21,735	51,160	0	268,374
Georgia																	
New investment	1,230	12,300	9,495	50,100	0	0	4,860	77,985	6,560	18,450	11,394	58,450	0	0	5,400	0	100,254
Replacement investment	3,280	1,025	1,393	6,680	0	1,525	648	14,551	3,280	1,025	1,393	6,680	3,060	1,525	648	1,950	19,561
Total initial investment	4,510	13,325	10,888	56,780	0	1,525	5,508	92,536	9,840	19,475	12,787	65,130	3,060	1,525	6,048	1,950	119,815
Annualized capital cost	2,881	3,485	3,276	13,100	0	1,165	1,620	25,527	3,752	4,715	3,654	14,410	3,060	1,165	1,728	1,590	34,074
Annual variable cost	45,881	87,618	71,786	62,900	0	6,080	36,750	311,015	59,752	118,542	80,069	69,190	18,804	6,080	39,200	6,920	398,557
Total annual cost	48,762	91,103	75,062	76,000	0	7,245	38,370	336,542	63,504	123,257	83,723	83,600	21,864	7,245	40,928	8,510	432,631
Hawaii																	
New investment	0	0	0	0	0	0	0	0	2,050	2,050	1,899	0	5,100	7,625	2,160	0	20,884
Replacement investment	246	205	127	0	0	0	0	373	574	205	633	1,670	1,020	1,525	540	13,650	19,817
Total initial investment	246	205	127	0	0	0	0	373	2,624	2,255	2,532	1,670	6,120	9,150	2,700	13,650	40,701
Annualized capital cost	201	205	126	0	0	0	0	532	804	615	1,008	1,310	4,080	2,330	972	0	11,119
Annual variable cost	3,201	5,154	2,761	0	0	0	0	11,116	12,804	15,462	22,088	6,290	12,536	24,320	22,050	0	115,550
Total annual cost	3,402	5,359	2,887	0	0	0	0	11,648	13,608	16,077	23,096	7,600	16,616	26,650	23,022	0	126,669

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Idaho																	
New investment	0	3,075	3,798	0	0	0	0	6,873	3,280	4,100	5,064	0	0	0	0	0	12,444
Replacement investment	1,230	0	0	1,670	0	0	0	2,900	2,214	0	0	5,010	0	0	0	0	7,224
Total initial investment	1,230	3,075	3,798	1,670	0	0	0	9,773	5,494	4,100	5,064	5,010	0	0	0	0	12,444
Annualized capital cost	1,005	615	756	1,310	0	0	0	3,686	2,345	820	1,008	3,930	0	0	0	0	8,103
Annual variable cost	16,005	15,462	16,566	6,290	0	0	0	54,323	37,345	20,616	22,088	18,870	0	0	0	0	98,919
Total annual cost	17,010	16,077	17,322	7,600	0	0	0	58,009	39,690	21,436	23,096	2,280	0	0	0	0	107,022
Illinois																	
New investment	0	0	5,064	0	5,100	30,500	6,480	47,144	3,690	12,300	13,293	50,100	35,700	45,750	7,020	9,750	177,603
Replacement investment	4,592	3,895	3,671	26,720	9,180	9,150	0	57,208	9,512	4,510	3,671	43,420	9,180	9,150	324	19,500	99,267
Total initial investment	4,592	3,895	8,735	26,720	14,280	36,650	6,480	104,352	13,202	16,810	16,964	93,520	44,880	54,900	7,344	29,250	276,870
Annualized capital cost	3,953	3,895	4,662	20,960	10,200	11,650	1,296	56,616	8,375	6,970	6,300	41,920	16,320	13,980	1,728	17,490	113,083
Annual variable cost	62,953	97,926	102,157	100,640	62,680	60,800	29,400	516,556	133,375	175,236	138,050	201,280	100,288	72,960	39,200	76,120	936,509
Total annual cost	66,906	101,821	106,819	121,600	72,880	72,450	30,696	573,172	141,750	182,206	144,350	243,200	116,608	86,940	40,928	93,610	1,049,592
Indiana																	
New investment	0	0	0	0	20,400	30,500	0	50,900	12,300	19,475	29,118	116,900	35,700	53,375	23,220	0	173,188
Replacement investment	3,690	3,075	3,545	16,700	0	0	1,404	28,414	7,708	4,920	5,444	30,060	0	0	3,996	0	52,128
Total initial investment	3,690	3,075	3,545	16,700	20,400	30,500	1,404	79,314	20,008	24,395	34,562	146,960	35,700	53,375	27,218	0	225,316
Annualized capital cost	3,015	3,075	3,528	13,100	4,080	4,660	1,404	32,862	8,308	8,815	11,214	41,920	7,140	8,155	7,560	0	93,112
Annual variable cost	48,015	77,310	77,308	62,900	25,072	24,320	31,850	346,775	132,308	221,622	245,729	201,280	43,876	42,560	171,500	0	1,058,875
Total annual cost	51,030	80,385	80,836	76,000	29,152	28,980	33,254	379,637	140,616	230,437	256,943	243,200	51,016	50,715	179,060	0	1,151,987
Iowa																	
New investment	820	9,225	5,064	0	0	7,625	0	22,734	5,330	11,275	5,697	16,700	0	7,625	1,080	0	47,707
Replacement investment	2,542	205	506	1,670	0	1,525	216	6,664	2,542	205	506	1,670	1,020	1,525	216	0	7,684
Total initial investment	3,362	9,430	5,570	1,670	0	9,150	216	29,398	7,872	11,480	6,203	18,370	1,020	9,150	1,296	0	55,391
Annualized capital cost	2,211	2,050	1,512	1,310	0	2,330	216	9,629	2,948	2,460	1,638	3,930	1,020	2,330	4,320	0	18,646
Annual variable cost	35,211	51,540	33,132	6,290	0	12,160	4,900	143,233	46,948	61,848	35,893	18,870	6,268	12,160	9,800	0	191,787
Total annual cost	37,422	53,590	34,644	7,600	0	14,490	5,116	152,862	49,896	64,308	37,531	22,800	7,288	14,490	10,232	0	210,433

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_x	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Kansas																	
New investment	0	7,175	0	0	0	15,250	0	22,425	10,250	9,225	17,724	16,700	10,200	30,500	17,280	9,750	121,629
Replacement investment	2,788	205	760	0	1,020	1,525	0	6,298	2,788	205	1,013	0	3,060	1,525	324	0	8,915
Total initial investment	2,788	7,380	760	0	1,020	16,775	0	28,723	13,038	9,430	18,737	16,700	13,260	32,025	17,604	9,750	130,544
Annualized capital cost	2,278	1,640	756	0	1,020	3,495	0	9,189	3,953	2,050	4,536	2,620	5,100	5,825	3,780	1,590	29,454
Annual variable cost	36,278	41,232	16,566	0	6,268	18,240	0	118,584	62,953	51,540	99,396	12,580	31,340	30,400	85,750	6,920	380,879
Total annual cost	38,556	42,872	17,322	0	7,288	21,735	0	127,773	66,906	53,590	103,932	15,200	36,440	36,225	89,530	8,510	410,333
Kentucky																	
New investment	0	0	0	0	0	0	0	0	35,670	15,375	56,970	91,850	56,100	68,625	58,860	9,750	393,200
Replacement investment	2,460	2,255	1,772	5,010	0	4,575	1,080	17,152	6,396	3,485	7,596	20,040	3,060	4,575	5,508	3,900	54,560
Total initial investment	2,460	2,255	1,775	5,010	0	4,575	1,080	17,152	42,066	18,860	64,566	111,890	59,160	73,200	64,368	13,650	447,760
Annualized capital cost	2,010	2,255	1,764	3,930	0	3,495	1,080	14,534	11,055	6,560	18,900	30,130	14,280	13,980	17,280	4,770	116,955
Annual variable cost	32,010	56,694	38,654	18,870	0	18,240	2,450	166,918	176,055	164,928	414,150	144,670	87,752	72,960	392,000	20,760	1,473,275
Total annual cost	34,020	58,949	40,418	22,800	0	21,735	3,530	181,452	187,110	171,488	433,050	174,800	102,032	86,940	409,280	25,530	1,590,230
Louisiana																	
New investment	0	0	3,165	0	0	0	0	3,165	1,640	1,025	5,064	8,350	0	23,704	0	0	23,704
Replacement investment	410	410	633	8,350	0	7,625	0	17,428	410	410	633	8,350	0	7,625	0	0	17,428
Total initial investment	410	410	3,798	8,350	0	7,625	0	20,593	2,050	1,435	5,697	16,700	0	31,329	0	0	41,132
Annualized capital cost	335	410	1,260	6,550	0	5,825	0	14,380	603	615	1,638	7,860	0	6,990	0	0	17,706
Annual variable cost	5,335	10,308	27,610	31,450	0	30,400	0	105,103	9,603	15,462	35,893	37,740	0	36,480	0	0	135,178
Total annual cost	5,670	10,718	28,870	38,000	0	36,225	0	119,483	10,206	16,077	37,531	45,600	0	43,470	0	0	152,884
Maine																	
New investment	2,870	2,050	3,165	8,350	0	0	0	16,435	6,560	3,075	10,761	8,350	0	0	0	0	28,746
Replacement investment	492	205	633	3,340	0	0	0	4,670	492	205	633	3,340	0	0	0	0	4,670
Total initial investment	3,362	2,255	3,798	11,690	0	0	0	21,105	7,052	3,275	11,394	11,690	0	0	0	0	33,416
Annualized capital cost	871	615	1,260	3,930	0	0	0	6,676	1,474	820	2,772	3,930	0	0	0	0	8,996
Annual variable cost	13,871	15,462	27,610	18,870	0	0	0	75,813	23,474	20,616	60,742	18,870	0	0	0	0	123,702
Total annual cost	14,742	16,077	28,870	22,800	0	0	0	82,489	24,948	21,436	63,514	22,800	0	0	0	0	132,694

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Maryland																	
New investment	0	0	0	0	0	0	0	0	4,920	9,225	8,862	75,150	40,800	45,750	7,560	0	192,267
Replacement investment	2,542	2,870	2,659	13,360	6,120	9,150	1,512	24,853	5,084	3,280	3,038	28,390	12,240	19,825	2,160	7,800	81,817
Total initial investment	2,542	2,870	2,659	13,360	6,120	9,150	1,512	24,853	10,004	12,505	11,900	103,540	53,040	65,575	9,720	7,800	274,084
Annualized capital cost	2,077	2,870	2,646	1,048	6,120	6,990	1,512	23,263	4,958	5,125	4,788	34,060	20,400	22,135	3,672	6,360	101,498
Annual variable cost	33,077	72,156	57,981	50,320	37,608	36,480	34,300	321,922	78,958	128,850	104,918	163,540	125,360	115,520	83,300	27,680	828,126
Total annual cost	35,154	75,026	60,627	60,800	43,728	43,470	35,812	345,185	83,916	133,975	109,706	197,600	145,760	137,655	86,972	34,040	929,624
Massachusetts																	
New investment	0	4,100	0	8,350	15,300	22,875	0	50,625	6,970	9,225	12,660	116,900	40,800	68,625	8,640	68,250	332,070
Replacement investment	2,788	2,460	2,659	13,360	3,060	4,575	1,728	30,630	3,772	2,460	5,824	13,360	3,060	4,575	4,968	0	38,019
Total initial investment	2,788	6,560	2,659	21,710	18,360	27,450	1,728	81,255	10,742	11,685	18,484	130,260	43,860	73,200	13,608	68,250	370,089
Annualized capital cost	2,278	3,280	2,646	11,790	6,120	6,990	1,728	34,832	4,221	4,305	8,316	28,820	11,220	13,980	6,696	11,130	88,688
Annual variable cost	36,278	82,464	57,981	56,610	37,608	36,480	39,200	346,621	67,221	108,234	182,226	138,380	68,948	72,960	151,900	48,440	838,309
Total annual cost	38,556	85,744	60,627	68,400	43,728	43,470	40,928	381,453	71,442	112,539	190,542	167,200	80,168	86,940	158,596	59,570	926,997
Michigan																	
New investment	0	11,275	7,596	0	0	0	8,100	26,971	19,270	28,700	18,990	91,850	51,000	38,125	16,200	39,000	303,135
Replacement investment	2,378	205	760	13,360	0	0	648	17,351	6,560	205	760	26,720	0	0	648	1,950	36,843
Total initial investment	2,378	11,480	8,356	13,360	0	0	8,748	44,322	25,830	28,905	19,750	118,570	51,000	38,125	16,843	40,950	339,978
Annualized capital cost	1,943	2,460	2,268	10,480	0	0	2,268	19,419	8,509	5,945	4,536	35,370	10,200	5,825	3,888	7,950	82,223
Annual variable cost	30,943	61,848	49,698	50,320	0	0	5,145	197,954	135,509	149,466	99,396	169,830	62,680	30,400	88,200	34,600	770,081
Total annual cost	32,886	64,308	51,966	60,800	0	0	53,718	217,373	144,018	155,411	103,932	205,200	72,880	36,225	92,088	42,550	852,304
Minnesota																	
New investment	0	0	633	0	0	0	540	1,173	0	1,025	3,165	41,750	0	15,250	540	0	61,730
Replacement investment	2,214	2,460	1,899	10,020	4,080	0	972	21,645	5,576	4,510	1,899	11,690	4,080	4,575	972	5,850	39,152
Total initial investment	2,214	2,460	2,532	10,020	4,080	0	1,512	22,818	5,576	5,535	5,064	53,440	4,080	19,825	1,512	5,850	100,882
Annualized capital cost	1,809	2,460	2,016	7,860	4,080	0	1,080	19,305	4,550	4,715	2,520	15,720	4,080	5,825	1,080	4,770	43,266
Annual variable cost	28,809	61,848	44,176	37,740	25,072	0	2,450	200,095	72,556	118,542	55,220	75,480	25,072	30,400	2,450	20,760	400,480
Total annual cost	30,618	64,308	46,192	45,600	29,152	0	3,530	219,400	77,112	123,257	57,740	91,200	29,152	36,225	3,530	25,530	443,746

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Mississippi																	
New investment	0	6,150	3,798	16,700	0	15,250	0	41,898	4,920	6,150	8,862	33,400	0	22,875	540	0	76,747
Replacement investment	902	0	127	0	0	0	0	1,029	1,394	0	127	0	0	0	0	0	1,521
Total initial investment	902	6,150	3,925	16,700	0	15,250	0	42,927	6,314	6,150	8,989	33,400	0	22,875	540	0	78,268
Annualized capital cost	737	1,230	882	2,620	0	2,330	0	7,799	1,943	1,230	1,890	5,240	0	3,495	108	0	13,906
Annual variable cost	11,737	30,924	19,327	12,580	0	12,160	0	86,728	30,943	30,924	41,415	25,160	0	18,240	2,450	0	149,132
Total annual cost	12,474	32,154	20,209	15,200	0	14,490	0	94,527	32,886	32,154	43,305	30,400	0	21,735	2,558	0	163,038
Missouri																	
New investment	0	0	3,165	0	0	0	2,160	5,325	2,870	5,125	0	33,400	15,300	30,500	540	29,250	116,985
Replacement investment	2,460	2,870	760	6,680	6,120	9,150	324	28,364	5,576	3,075	760	11,690	10,200	13,725	324	17,550	62,900
Total initial investment	2,460	2,870	3,925	6,680	6,120	9,150	2,484	33,689	8,446	8,200	760	45,090	25,500	44,225	864	46,800	179,885
Annualized capital cost	2,010	2,870	1,386	5,240	6,120	6,990	756	25,372	5,025	4,100	756	14,410	13,260	15,145	432	19,080	72,208
Annual variable cost	32,010	72,156	30,371	25,160	37,608	36,480	17,150	250,935	80,025	103,080	16,566	69,190	81,484	79,040	9,800	83,040	522,225
Total annual cost	34,020	75,026	31,757	30,400	43,728	43,470	17,906	276,307	85,050	107,180	17,322	83,600	94,744	94,185	10,232	10,212	594,433
Montana																	
New investment	2,460	2,050	5,697	8,350	0	0	0	18,557	2,870	2,050	5,697	16,700	0	0	0	0	27,317
Replacement investment	574	205	253	3,340	0	0	0	4,372	574	205	253	3,340	0	0	0	0	4,372
Total initial investment	3,034	2,255	5,950	11,690	0	0	0	22,929	3,444	2,255	5,950	20,040	0	0	0	0	31,689
Annualized capital cost	871	615	1,386	3,930	0	0	0	6,802	938	615	1,386	5,240	0	0	0	0	8,179
Annual variable cost	13,871	15,462	30,371	18,870	0	0	0	78,574	14,938	15,462	30,371	25,160	0	0	0	0	85,931
Total annual cost	14,742	16,077	31,757	22,800	0	0	0	85,376	15,876	16,077	31,757	30,400	0	0	0	0	94,110
[illegible]																	
[illegible]vestment	0	0	3,165	8,350	0	0	2,700	14,215	0	1,025	3,165	8,350	0	0	3,240	0	15,780
[illegible]nt investment	984	615	127	0	0	0	108	1,834	2,378	615	127	0	0	0	108	0	3,228
Total initial investment	984	615	3,292	8,350	0	0	2,808	16,049	2,378	1,640	3,292	8,350	0	0	3,348	0	19,008
Annualized capital cost	804	615	756	1,310	0	0	648	4,133	1,943	820	756	1,310	0	0	756	0	5,585
Annual variable cost	12,804	15,462	16,566	6,290	0	0	14,700	65,822	30,943	20,616	16,566	6,290	0	0	1,715	0	76,130
Total annual cost	13,608	16,077	17,322	7,600	0	0	15,348	69,955	32,886	21,436	17,322	760	0	0	17,906	0	81,715

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Nevada																	
New investment	0	1,025	0	16,700	5,100	0	0	22,825	0	2,050	0	16,700	5,100	7,625	0	0	31,475
Replacement investment	1,066	410	760	0	1,020	3,050	540	6,846	2,788	410	760	0	1,020	3,050	540	5,850	14,418
Total initial investment	1,066	1,435	760	16,700	6,120	3,050	540	29,671	2,788	2,460	760	16,700	6,120	10,675	540	5,850	45,893
Annualized capital cost	871	615	756	2,620	2,040	2,330	540	9,772	2,278	820	756	2,620	2,040	3,495	540	4,770	17,319
Annual variable cost	13,871	15,462	16,566	12,580	12,536	12,160	12,250	95,425	36,278	20,616	16,566	12,580	12,536	18,240	12,250	20,760	149,826
Total annual cost	14,742	16,077	17,322	15,200	14,576	14,490	12,790	105,197	38,556	21,436	17,322	15,200	14,576	21,735	12,790	25,530	167,145
New Hampshire																	
New investment	0	2,050	1,899	16,700	0	0	0	20,649	2,870	6,150	5,697	33,400	10,200	7,625	6,480	0	72,422
Replacement investment	656	0	505	0	0	0	0	1,162	2,050	0	506	0	0	0	108	0	2,664
Total initial investment	656	2,050	2,405	16,700	0	0	0	21,811	4,920	6,150	6,203	33,400	10,200	7,625	6,588	0	75,086
Annualized capital cost	536	410	882	2,620	0	0	0	4,448	2,144	1,230	1,638	5,240	2,040	1,165	1,404	0	14,861
Annual variable cost	8,536	10,308	19,327	12,580	0	0	0	50,751	34,144	30,924	35,893	25,160	12,536	6,080	31,850	0	176,587
Total annual cost	9,072	10,718	20,209	15,200	0	0	0	55,199	36,288	32,154	37,531	30,400	14,576	7,245	33,254	0	191,448
New Jersey																	
New investment	0	0	8,229	0	0	22,875	3,780	12,009	0	0	3,165	8,350	0	22,873	4,320	0	38,710
Replacement investment	1,558	1,025	0	11,690	8,160	432	0	31,094	4,100	4,510	0	2,659	36,740	6,100	0	0	54,109
Total initial investment	1,558	1,025	8,229	11,690	8,160	23,307	3,780	43,103	4,100	4,510	3,165	11,009	36,740	28,973	4,320	0	92,819
Annualized capital cost	1,273	1,025	1,638	9,170	8,160	8,155	756	30,177	3,350	4,510	630	28,820	22,440	8,155	864	0	68,769
Annual variable cost	20,273	25,770	35,893	44,030	50,144	42,560	17,150	235,820	5,335	113,388	13,805	138,380	137,896	42,560	19,600	0	470,964
Total annual cost	21,546	26,795	37,531	53,200	58,304	50,715	17,906	265,997	56,700	117,898	14,435	167,200	160,336	50,715	20,464	0	539,733
New Mexico																	
New investment	0	1,025	1,266	0	0	7,625	0	9,916	4,100	7,175	10,128	16,700	5,100	7,625	6,480	0	57,305
Replacement investment	1,312	410	760	1,670	1,020	3,050	0	8,222	3,444	410	760	5,010	2,040	3,050	648	0	15,362
Total initial investment	1,312	1,435	2,026	1,670	1,020	10,675	0	18,138	7,544	7,585	10,888	21,710	7,140	10,765	7,128	0	72,667
Annualized capital cost	1,072	615	1,008	1,310	1,020	3,495	0	8,520	3,484	1,845	2,772	6,550	3,060	3,495	1,944	0	23,150
Annual variable cost	17,072	15,462	22,088	6,290	6,268	18,240	0	85,420	55,484	46,386	60,742	31,450	18,804	18,240	44,100	0	275,206
Total annual cost	18,144	16,077	23,096	7,600	7,288	21,735	0	93,940	58,968	48,231	63,514	38,000	21,864	21,735	46,044	0	298,356

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
New York																	
New investment	0	0	14,559	0	0	53,375	10,260	78,194	43,460	10,250	3,165	283,900	35,700	106,750	11,340	0	494,560
Replacement investment	5,904	5,125	80,138	31,730	13,260	13,725	756	150,638	18,860	9,635	760	75,150	22,440	13,725	756	0	141,326
Total initial investment	5,904	5,125	94,697	31,730	13,260	67,100	11,016	228,832	62,320	19,885	3,925	359,050	58,140	120,475	12,096	0	635,886
Annualized capital cost	4,824	1,675	4,914	24,890	13,260	18,640	2,808	71,011	22,512	11,685	1,386	103,490	29,580	26,795	3,024	0	198,472
Annual variable cost	76,824	26,675	107,679	119,510	81,484	97,280	63,700	573,152	358,512	293,778	30,371	496,910	181,772	139,840	68,600	0	1,569,783
Total annual cost	81,648	28,350	112,593	144,400	94,744	11,592	66,508	644,163	381,024	305,463	31,757	600,400	211,352	166,635	71,624	0	1,768,255
North Carolina																	
New investment	0	0	0	0	0	0	0	0	45,510	28,700	76,593	0	4,080	3,495	0	0	158,378
Replacement investment	4,428	3,485	1,266	1,670	0	466	0	11,315	4,428	3,485	1,266	0	0	466	0	0	9,645
Total initial investment	4,428	3,485	1,266	1,670	0	466	0	11,315	49,938	32,185	77,859	0	4,080	3,961	0	0	168,023
Annualized capital cost	3,618	3,485	1,260	1,310	0	2,330	0	12,003	11,055	9,225	16,506	0	4,080	5,825	0	0	46,691
Annual variable cost	57,618	87,618	27,610	6,290	0	12,160	0	191,296	176,055	231,930	361,691	0	25,072	30,400	0	0	825,148
Total annual cost	61,236	91,103	28,870	7,600	0	14,490	0	203,299	187,110	241,155	378,197	0	29,152	36,225	0	0	871,839
North Dakota																	
New investment	0	2,050	633	0	0	0	0	2,683	0	2,050	633	0	0	0	540	0	3,223
Replacement investment	492	0	127	0	0	0	0	619	1,230	0	127	0	0	0	0	0	1,357
Total initial investment	492	2,050	760	0	0	0	0	3,302	1,230	2,050	760	0	0	0	0	0	4,580
Annualized capital cost	402	410	252	0	0	0	0	1,064	1,005	410	252	0	0	0	108	0	1,775
Annual variable cost	6,402	10,308	5,522	0	0	0	0	22,232	16,005	10,308	5,522	0	0	0	2,450	0	34,285
Total annual cost	6,804	10,718	5,774	0	0	0	0	23,296	17,010	10,718	5,774	0	0	0	2,558	0	36,060
Ohio																	
New investment	0	20,500	9,495	0	0	0	0	29,995	21,730	29,725	37,347	0	0	0	0	0	88,802
Replacement investment	6,396	2,460	3,165	0	0	0	0	12,021	16,564	2,460	4,431	40,080	0	0	0	0	63,535
Total initial investment	6,396	22,960	12,660	0	0	0	0	42,016	38,294	32,185	41,778	40,080	0	0	0	0	152,337
Annualized capital cost	5,226	6,560	5,040	0	0	0	0	16,826	17,085	8,405	11,844	31,440	0	0	0	0	68,774
Annual variable cost	83,226	164,928	110,440	0	0	0	0	358,594	272,085	211,314	259,534	150,960	0	0	0	0	893,893
Total annual cost	88,452	171,488	115,480	0	0	0	0	375,420	289,170	219,719	271,378	182,400	0	0	0	0	962,667

Table 3-2 (continued)

	Required								Proposed							
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2	Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb Cont	
Oklahoma																
New investment	0	4,100	0	0	0	15,250	0	19,350	7,790	7,175	4,431	25,050	5,100	15,250	0 0	39,746
Replacement investment	1,968	615	886	0	0	3,050	0	6,519	6,478	615	1,013	0	3,060	3,050	0 0	14,216
Total initial investment	1,968	4,715	886	0	0	18,300	0	25,869	14,268	7,785	5,444	25,050	8,160	18,300	0 0	53,962
Annualized capital cost	1,608	1,435	882	0	0	4,660	0	8,585	6,566	2,050	1,890	3,930	4,080	4,660	0 0	23,176
Annual variable cost	25,608	36,078	19,327	0	0	24,320	0	105,333	104,566	51,540	56,415	18,870	25,072	24,320	0 0	280,783
Total annual cost	27,216	37,513	20,209	0	0	28,980	0	113,918	111,132	53,590	58,305	22,800	29,152	28,980	0 0	303,959
Oregon																
New investment	0	4,100	633	0	0	7,625	0	12,358	0	4,100	1,266	0	5,100	7,625	2,160 0	20,251
Replacement investment	1,640	1,025	633	1,670	3,060	3,050	0	8,018	2,214	1,025	633	1,670	3,060	3,050	0 0	11,652
Total initial investment	1,640	5,125	1,266	1,670	3,060	10,675	0	20,376	2,214	5,125	1,899	1,670	8,160	10,675	2,160 0	31,903
Annualized capital cost	1,340	1,845	756	1,310	3,060	3,495	0	11,806	1,809	1,845	882	1,310	4,080	3,495	432 0	13,853
Annual variable cost	21,340	46,386	16,566	6,290	18,240	18,240	0	127,626	28,809	46,386	19,327	6,290	25,072	18,240	9,800 0	153,924
Total annual cost	22,680	48,231	17,322	7,600	21,864	21,735	0	139,432	30,618	48,231	20,209	7,600	29,152	21,735	10,232 0	167,777
Pennsylvania																
New investment	0	18,450	17,724	0	0	30,500	24,300	90,974	14,350	46,125	0	350,700	193,800	282,125	0 516,750	140,385
Replacement investment	5,576	3,075	0	23,380	11,220	10,675	0	53,926	6,642	3,075	0	28,390	12,240	10,675	0 13,650	74,672
Total initial investment	5,576	21,525	17,724	23,380	11,220	41,175	24,300	144,900	20,992	49,200	0	379,090	206,040	292,800	0 530,400	215,057
Annualized capital cost	4,556	6,765	3,528	18,340	11,220	12,815	4,860	62,084	7,772	12,300	0	77,290	51,000	51,260	0 95,400	295,022
Annual variable cost	72,556	170,082	77,308	88,060	68,948	66,880	110,250	654,084	123,772	309,240	0	371,110	313,400	267,520	0 415,200	1,800,242
Total annual cost	77,112	176,847	80,836	106,400	80,168	79,695	115,110	716,168	131,544	321,540	0	448,400	364,400	318,780	0 510,600	2,095,264
Puerto Rico																
New investment	0	1,025	1,266	8,350	0	0	0	10,641	7,380	7,175	1,266	158,650	5,100	0	8,640 0	188,211
Replacement investment	246	0	127	0	0	0	0	373	328	0	127	0	0	0	324 0	779
Total initial investment	246	1,025	1,393	8,350	0	0	0	11,014	7,708	7,175	1,393	158,650	5,100	0	8,964 0	188,990
Annualized capital cost	201	205	378	1,310	0	0	0	2,094	1,474	1,435	378	24,890	1,020	0	2,052 0	31,249
Annual variable cost	3,201	5,154	8,283	6,290	0	0	0	22,928	23,474	36,078	8,283	119,510	6,268	0	46,550 0	240,163
Total annual cost	3,402	5,359	8,661	7,600	0	0	0	25,022	24,948	37,513	8,661	144,400	7,288	0	48,602 0	271,412

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Rhode Island																	
New investment	0	4,100	0	16,700	0	0	0	20,800	2,870	4,100	1,899	33,400	20,400	30,500	3,780	0	96,949
Replacement investment	574	0	633	0	0	0	648	1,855	1,476	0	2,279	0	0	0	1,944	0	5,699
Total initial investment	574	4,100	633	0	0	0	648	22,655	4,346	4,100	4,178	33,400	20,400	30,500	5,724	0	102,648
Annualized capital cost	469	820	630	2,620	0	0	648	4,620	1,675	820	2,646	5,240	4,080	4,660	2,700	0	21,821
Annual variable cost	7,469	20,616	13,805	12,580	0	0	14,700	69,170	26,675	20,616	57,981	25,160	25,072	24,320	61,250	0	241,074
Total annual cost	7,938	21,436	14,435	15,200	0	0	15,348	73,790	28,350	21,436	60,627	30,400	29,152	28,980	63,950	0	262,895
South Carolina																	
New investment	0	5,125	0	8,350	0	7,625	0	21,100	5,330	7,175	12,027	33,400	0	7,625	0	0	65,557
Replacement investment	3,280	615	2,152	3,340	0	0	0	9,387	4,510	615	2,532	3,340	0	0	0	0	6,487
Total initial investment	3,280	5,740	2,152	11,690	0	7,625	0	30,487	9,840	7,790	14,559	36,740	0	7,625	0	0	72,044
Annualized capital cost	2,680	1,640	2,142	3,930	0	1,165	0	11,557	4,556	2,050	4,914	7,860	0	1,165	0	0	20,545
Annual variable cost	42,680	41,232	46,937	18,870	0	6,080	0	1,155,799	72,556	51,540	107,679	37,740	0	6,080	0	0	275,595
Total annual cost	45,360	42,872	49,079	22,800	0	7,245	0	167,356	77,112	53,590	112,593	45,600	0	7,245	0	0	296,140
South Dakota																	
New investment	1,640	1,025	2,532	0	0	0	0	5,197	1,640	1,025	2,532	0	0	0	0	0	5,197
Replacement investment	164	0	0	0	0	0	0	164	164	0	0	0	0	0	0	0	164
Total initial investment	1,804	1,025	2,532	0	0	0	0	5,361	1,804	1,025	2,532	0	0	0	0	0	5,361
Annualized capital cost	402	205	504	0	0	0	0	1,111	402	205	504	0	0	0	0	0	1,111
Annual variable cost	6,402	5,154	11,044	0	0	0	0	22,600	6,402	5,154	11,044	0	0	0	0	0	22,600
Total annual cost	6,804	5,359	11,548	0	0	0	0	23,711	6,804	5,359	11,548	0	0	0	0	0	23,711
Tennessee																	
New investment	0	12,300	5,697	16,700	0	7,625	0	42,322	1,640	12,300	25,320	33,400	5,100	22,875	10,800	19,500	130,935
Replacement investment	3,198	820	633	3,340	0	6,100	1,188	14,459	7,544	820	633	3,340	4,080	6,100	8,640	0	31,157
Total initial investment	3,198	13,120	6,330	20,040	0	13,725	1,188	56,781	9,184	13,120	25,953	36,740	9,180	28,975	19,440	19,500	162,092
Annualized capital cost	2,613	3,280	1,764	5,240	0	5,825	1,188	19,910	6,432	3,280	5,670	7,860	5,100	8,155	3,888	3,180	43,565
Annual variable cost	41,613	82,464	38,654	25,160	0	30,400	26,950	245,241	102,432	82,464	124,245	37,740	31,340	42,560	88,200	13,840	522,821
Total annual cost	44,226	85,744	40,418	30,400	0	36,225	28,138	265,151	108,864	85,744	129,915	45,600	36,440	50,715	92,088	17,020	566,386

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Texas																	
New investment	0	17,425	0	100,200	5,100	144,875	0	267,600	33,210	22,550	75,960	509,350	402,900	617,625	0	770,250	2,431,845
Replacement investment	4,264	615	4,684	0	0	0	0	95,632	11,480	615	6,457	0	0	0	0	0	18,552
Total initial investment	4,264	18,040	4,684	100,200	5,100	144,875	0	277,163	44,690	23,165	82,417	509,350	402,900	617,625	0	770,250	2,450,397
Annualized capital cost	3,484	4,100	4,662	15,720	1,020	22,135	0	51,121	14,807	5,125	21,546	79,910	80,580	94,365	0	125,610	421,943
Annual variable cost	55,484	103,080	102,157	75,480	6,268	115,520	0	457,989	235,807	128,850	472,131	383,690	495,172	492,480	0	546,680	2,754,810
Total annual cost	58,968	107,180	106,819	91,200	7,268	137,655	0	509,110	250,614	133,975	493,677	463,600	575,752	586,845	0	672,290	3,176,753
Utah																	
New investment	1,230	0	3,165	0	0	0	3,240	7,635	4,510	0	6,963	8,350	5,100	7,625	5,940	9,750	48,238
Replacement investment	656	615	506	3,340	2,040	3,050	432	10,639	656	1,025	506	8,350	4,080	6,100	432	9,750	30,899
Total initial investment	1,886	615	3,671	340	2,040	3,050	3,672	18,274	5,166	1,025	12,469	16,700	9,180	13,725	6,372	19,500	79,137
Annualized capital cost	737	615	1,134	2,620	2,040	216	1,080	8,442	1,273	1,025	1,890	7,860	5,100	5,825	1,620	9,540	34,133
Annual variable cost	11,737	15,462	24,849	12,580	12,536	4,900	24,500	106,564	20,273	25,770	41,415	37,740	31,340	30,400	36,750	41,520	265,208
Total annual cost	12,474	16,077	25,983	15,200	14,576	5,116	25,580	115,006	21,546	26,795	43,305	45,600	36,440	36,225	38,370	51,060	299,341
Vermont																	
New investment	0	0	1,899	0	0	0	0	1,899	1,230	1,025	1,266	33,400	0	0	0	0	36,921
Replacement investment	328	205	127	1,670	0	0	0	2,330	574	205	127	3,340	1,020	1,525	0	1,950	8,741
Total initial investment	328	205	2,026	1,670	0	0	0	4,229	1,804	1,230	1,393	36,740	1,020	1,525	0	1,950	45,662
Annualized capital cost	268	205	504	1,310	0	0	0	2,287	670	410	376	7,860	1,020	1,165	0	1,590	13,093
Annual variable cost	4,268	5,154	11,044	6,290	0	0	0	26,756	10,670	10,308	8,283	37,740	6,268	6,080	0	6,920	86,269
Total annual cost	4,536	5,359	11,548	7,600	0	0	0	29,043	11,270	10,718	8,661	45,600	7,288	7,245	0	8,510	99,362
Virginia																	
New investment	0	9,225	0	25,050	0	22,875	540	57,690	14,350	12,300	15,192	58,450	20,400	22,875	9,720	0	153,287
Replacement investment	4,510	2,255	2,152	3,340	2,040	6,100	2,160	22,557	5,986	2,255	2,912	3,340	3,060	6,100	2,160	3,900	29,713
Total initial investment	4,510	11,480	2,152	28,390	2,040	28,975	2,700	80,247	20,336	14,555	18,104	61,790	23,460	28,975	11,880	3,900	183,000
Annualized capital cost	3,685	4,100	2,142	6,550	2,040	8,155	2,268	28,940	7,236	4,715	5,922	11,790	7,140	8,155	4,104	3,180	52,242
Annual variable cost	58,685	103,080	46,937	31,450	12,536	42,560	51,450	346,698	115,236	118,542	129,767	56,610	43,876	42,560	93,100	13,840	613,531
Total annual cost	62,370	107,180	49,079	38,000	14,576	50,715	53,718	375,638	122,472	123,257	135,689	68,400	51,016	50,715	97,204	17,020	665,773

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
Washington																	
New investment	0	0	6,963	0	0	0	5,400	12,363	410	1,025	2,532	8,350	0	0	5,400	0	17,717
Replacement investment	2,542	2,870	0	5,010	7,140	7,625	0	25,187	5,822	3,690	0	33,460	9,180	10,675	0	5,850	68,617
Total initial investment	2,542	2,870	6,963	5,010	7,140	7,625	5,400	37,550	6,232	4,715	2,532	41,750	9,180	10,675	5,400	5,850	86,334
Annualized capital cost	2,077	2,870	1,386	3,930	7,140	5,825	1,080	24,308	4,828	3,895	504	27,510	9,180	8,155	1,080	4,770	59,922
Annual variable cost	33,077	72,156	30,371	18,870	43,876	30,400	24,500	253,250	76,824	97,926	11,044	132,090	56,412	42,560	2,450	20,760	440,066
Total annual cost	35,154	75,026	31,757	22,800	51,016	36,225	25,580	277,558	81,648	101,821	11,548	159,600	65,592	50,715	25,580	25,530	499,988
West Virginia																	
New investment	0	0	0	16,700	0	0	0	16,700	1,230	2,050	5,064	16,700	0	0	0	0	25,044
Replacement investment	1,968	1,025	1,266	0	0	0	0	4,259	2,788	4,510	1,646	0	1,020	4,575	0	0	13,519
Total initial investment	1,968	1,025	1,266	16,700	0	0	0	20,959	4,018	6,560	6,710	16,700	1,020	4,575	0	0	38,563
Annualized capital cost	1,608	1,025	1,260	2,620	0	0	0	6,513	14,874	4,920	2,646	2,620	1,020	3,495	0	0	29,575
Annual variable cost	25,608	25,770	27,610	12,580	0	0	0	91,568	39,479	123,696	57,981	12,580	6,268	18,240	0	0	258,244
Total annual cost	27,216	26,795	28,870	15,200	0	0	0	98,081	54,353	128,616	60,627	15,200	7,288	21,735	0	0	287,819
Wisconsin																	
New investment	0	50,225	0	0	0	0	1,620	51,845	1,230	9,225	5,064	41,750	40,800	38,125	540	48,750	185,484
Replacement investment	1,968	615	1,013	1,670	0	6,100	756	12,122	5,822	615	2,785	6,680	1,020	9,150	756	390	27,218
Total initial investment	1,968	50,840	1,013	1,670	0	6,100	2,376	63,967	7,052	9,840	7,849	48,430	41,820	47,275	1,296	49,140	212,702
Annualized capital cost	1,608	2,050	1,008	1,310	0	4,660	1,080	11,716	4,958	2,460	3,780	11,790	9,180	12,815	864	9,540	55,387
Annual variable cost	25,608	51,540	22,088	6,290	0	24,320	24,500	154,346	78,958	61,848	82,830	56,610	56,412	66,880	19,600	41,520	464,658
Total annual cost	27,216	53,590	23,096	7,600	0	28,980	25,580	166,062	83,916	64,308	86,610	68,400	65,592	79,695	20,464	51,060	520,045
Wyoming																	
New investment	410	2,050	1,266	0	0	0	0	3,726	1,640	2,050	1,266	0	0	0	0	0	4,956
Replacement investment	492	0	127	0	0	0	0	619	492	0	127	0	0	0	0	0	619
Total initial investment	902	2,050	1,393	0	0	0	0	4,345	2,132	2,050	1,393	0	0	0	0	0	5,575
Annualized capital cost	469	410	378	0	0	0	0	1,257	670	410	378	0	0	0	0	0	1,458
Annual variable cost	7,469	10,308	8,283	0	0	0	0	26,060	10,670	10,308	8,283	0	0	0	0	0	29,261
Total annual cost	7,938	10,718	8,661	0	0	0	0	27,317	11,340	10,718	8,661	0	0	0	0	0	30,719

Table 3-2 (continued)

	Required								Proposed								
	PM		SO_2		CO	O_x	NO_2	Totals	PM		SO_2		CO	O_x	NO_2		Totals
	HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb		HiVol	Tape	Bubb	Cont	Cont	Cont	Bubb	Cont	
American Samoa																	
New investment	410	0	633	0	0	0	0	1,043	410	0	633	0	0	0	0	0	1,043
Replacement investment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total initial investment	410	0	633	0	0	0	0	1,043	410	0	633	0	0	0	0	0	1,043
Annualized capital cost	67	0	126	0	0	0	0	193	67	0	126	0	0	0	0	0	193
Annual variable cost	1,067	0	2,761	0	0	0	0	3,828	1,067	0	2,761	0	0	0	0	0	3,828
Total annual cost	1,134	0	2,887	0	0	0	0	4,021	1,134	0	2,887	0	0	0	0	0	4,021
Guam																	
New investment	410	0	1,899	8,350	0	0	0	10,659	820	1,025	1,899	8,350	0	0	0	0	12,094
Replacement investment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total initial investment	410	0	1,899	8,350	0	0	0	10,659	820	1,025	1,899	8,350	0	0	0	0	12,094
Annualized capital cost	67	0	378	1,310	0	0	0	1,755	134	205	378	1,310	0	0	0	0	2,027
Annual variable cost	1,067	0	8,283	6,290	0	0	0	15,640	2,134	5,154	8,283	6,290	0	0	0	0	21,861
Total annual cost	1,134	0	8,661	7,600	0	0	0	17,395	2,268	5,359	8,661	7,600	0	0	0	0	23,888
U.S. Virgin Island																	
New investment	0	0	633	8,350	0	0	0	8,983	0	0	633	8,350	0	0	0	0	8,983
Replacement investment	246	205	253	0	0	0	0	704	492	205	253	0	0	0	0	0	697
Total initial investment	246	205	886	8,350	0	0	0	9,687	492	205	886	0	0	0	0	0	9,680
Annualized capital cost	201	205	378	1,310	0	0	0	2,094	402	205	378	1,310	0	0	0	0	2,295
Annual variable cost	3,201	5,154	8,283	6,290	0	0	0	22,928	6,402	5,154	8,283	6,290	0	0	0	0	26,129
Total annual cost	3,402	5,359	8,661	7,600	0	0	0	25,022	6,804	5,359	8,661	7,600	0	0	0	0	28,424

3.3 Aggregate National Air Monitoring Cost Estimates

Aggregate capital requirements and annualized costs are reported in this section by state and by EPA regional offices. Table 3-3 reports these cost estimates under the assumption that the minimum federal air quality monitoring system requirements will just be met. Table 3-4 gives cost projections under the assumption that the states adhere to the network proposals as given in their respective SIP's.

The first two cost elements shown in the group of items identified as capital requirements, i.e., new instruments and replacement instruments, are simply transcribed from the totals columns of Table 3-2. The same comment is applicable to the first two items, annual capital charge and instrument operation, among annualized costs.

The instrument housing costs were estimated by using the data generated in compiling Table 3-1 in conjunction with the cost estimates presented in Section 2.2.1. Initial personnel costs were similarly developed in using the data on total numbers of instruments, as reported in Table 3-1, along with the cost estimates indicated in Section 2.2.4. These included: (1) documentation costs, (2) system engineering costs, and (3) system specification costs and training costs.

The final two cost items arrayed in Tables 3-3 and 3-4 are data processing and travel costs. The cost factors for each of these items are summarized in Sections 2.2.2 and 2.2.3. These cost factors were simply multiplied by the appropriate number of samplers or estimated number of sites from Table 3-1.

Table 3-3. ESTIMATED CAPITAL REQUIREMENTS AND ANNUALIZED COSTS OF IMPLEMENTING FEDERAL AIR QUALITY MONITORING SYSTEM REQUIREMENTS

Regions and States or U.S. Territories	Capital requirements					Annualized costs				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region I										
Connecticut	40,381	19,206	6,750	10,300	76,637	23,390	205,269	19,800	17,700	266,159
Maine	16,435	4,670	3,900	5,900	30,905	6,676	75,813	11,700	8,900	103,089
Massachusetts	50,625	30,630	7,500	6,200	94,955	34,832	346,621	32,400	28,900	442,753
New Hampshire	20,649	1,162	5,000	3,600	30,411	4,448	50,751	5,700	6,900	67,799
Rhode Island	20,800	1,855	5,000	3,800	31,455	4,620	69,170	7,200	4,300	85,290
Vermont	1,899	2,330	0	1,900	6,129	2,287	26,756	300	4,000	33,343
Total	150,789	59,853	28,150	31,700	270,492	76,253	774,380	77,100	70,700	998,433
Region II										
New Jersey	12,009	31,094	89,000	10,300	142,403	30,177	235,820	19,800	21,500	307,297
New York	78,194	150,638	5,650	22,700	258,182	71,011	573,152	63,000	70,400	777,563
Puerto Rico	10,641	373	2,500	2,100	15,614	2,094	22,928	2,400	2,000	29,422
U.S. Virgin Is.	8,983	704	350	500	10,537	2,094	22,928	2,400	2,800	30,222
Total	109,827	182,809	98,500	35,600	426,736	105,376	854,828	87,600	96,700	1,144,504
Region III										
Delaware	0	5,027	0	0	5,027	4,261	34,965	0	0	39,226
Dist. of Columbia	3,519	3,860	1,050	2,600	11,029	4,875	48,847	4,500	4,000	62,222
Maryland	0	24,853	0	0	24,853	23,263	321,922	30,000	30,000	405,185
Pennsylvania	90,974	53,926	18,400	41,100	204,400	62,084	654,084	63,000	67,300	846,468
Virginia	57,690	22,557	7,500	9,700	97,447	28,940	346,698	38,100	37,900	451,638
West Virginia	16,700	4,259	0	2,100	23,059	6,513	91,568	12,300	10,200	120,581
Total	168,883	114,482	26,950	55,500	365,815	129,936	1,498,084	147,900	149,400	1,925,320

Table 3-3 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region IV										
Alabama	77,629	6,731	12,500	15,300	112,160	19,173	222,591	23,100	24,700	289,564
Florida	11,980	19,550	2,450	6,800	40,780	20,266	325,712	26,700	12,900	385,578
Georgia	77,985	14,551	24,600	18,500	135,636	25,527	311,015	33,600	34,300	404,442
Kentucky	0	17,152	0	0	17,152	14,534	166,918	21,300	15,600	218,352
Mississippi	41,898	1,029	6,400	7,600	56,927	7,799	86,728	5,100	9,200	108,827
North Carolina	0	11,315	0	0	11,315	12,003	191,296	25,000	22,400	250,699
South Carolina	21,100	9,387	2,500	4,600	37,587	11,557	155,799	20,700	21,500	209,556
Tennessee	42,322	14,459	7,450	6,800	71,031	19,910	245,241	26,700	26,400	318,251
Total	272,914	94,174	55,900	59,600	482,588	130,769	1,705,300	182,200	167,000	2,185,269
Region V										
Illinois	47,144	57,208	4,950	12,100	121,402	56,616	516,556	48,000	52,200	673,372
Indiana	50,900	28,414	5,000	5,600	89,914	32,862	346,775	35,700	37,100	452,437
Michigan	26,971	17,351	4,200	14,700	63,222	19,419	197,954	26,400	27,500	271,273
Minnesota	1,173	21,645	350	900	24,068	19,305	200,095	22,500	18,600	260,500
Ohio	29,995	12,021	5,250	16,400	63,666	16,826	358,594	45,000	38,400	458,820
Wisconsin	51,845	12,122	1,050	7,400	72,417	11,716	154,346	17,100	45,400	228,562
Total	208,028	148,761	20,800	57,100	434,689	156,744	1,774,320	194,700	219,200	2,344,964
Region VI										
Arkansas	4,489	865	700	2,600	8,654	1,625	33,405	4,800	4,700	44,530
Louisiana	3,165	17,428	0	3,300	23,893	14,380	105,103	8,100	12,000	139,583
New Mexico	9,916	8,222	5,000	2,100	25,238	8,520	85,420	9,600	10,900	114,440
Oklahoma	19,350	6,519	5,000	3,800	34,669	8,585	105,333	12,600	16,100	142,618
Texas	267,600	95,632	42,500	30,400	436,132	51,121	457,989	42,300	31,700	583,110
Total	304,520	128,666	53,200	42,200	528,586	84,231	787,250	77,400	75,400	1,024,281

Table 3-3 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region VII										
Iowa	22,734	6,664	4,950	8,600	42,948	9,629	143,233	18,000	18,200	189,062
Kansas	22,425	6,298	5,000	5,700	39,423	9,189	118,584	15,600	17,200	160,573
Missouri	5,325	28,364	1,400	4,100	39,189	25,372	250,935	23,400	21,400	321,107
Nebraska	14,215	1,834	1,750	4,900	22,699	4,133	65,822	8,400	7,900	86,255
Total	64,699	43,160	11,700	23,300	142,859	48,323	578,574	65,400	64,700	756,997
Region VIII										
Colorado	32,956	5,706	5,350	7,200	51,212	10,807	123,983	14,400	17,200	166,390
Montana	18,557	4,372	11,750	8,000	42,679	6,802	78,574	900	6,600	92,876
North Dakota	2,683	619	350	1,500	5,152	1,064	22,232	3,000	3,100	29,396
South Dakota	5,197	164	1,400	3,600	10,361	1,111	22,600	3,300	2,400	29,411
Utah	7,635	10,639	1,750	5,500	25,524	8,442	106,564	11,700	11,200	137,906
Wyoming	3,726	619	700	2,000	7,045	1,257	26,060	3,600	3,100	34,017
Total	70,754	22,119	21,300	27,800	141,973	29,483	380,013	36,900	43,600	489,996
Region IX										
American Samoa	1,043	0	350	900	2,293	193	3,828	600	400	5,021
Arizona	23,227	17,125	7,100	8,500	55,952	18,643	189,641	17,700	17,500	243,484
California	25,220	89,031	7,700	23,700	145,651	83,542	687,253	58,800	78,500	908,095
Guam	10,659	0	350	2,700	13,709	1,755	15,640	1,500	2,500	21,395
Hawaii	0	373	0	0	373	532	11,116	1,500	1,200	14,348
Nevada	22,825	6,846	2,500	2,700	34,871	9,772	95,425	9,900	11,000	126,097
Total	82,974	113,375	18,000	38,500	252,849	114,437	1,002,903	90,000	111,100	1,318,440

Table 3-3 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region X										
Alaska	20,715	619	6,400	5,700	33,434	4,233	51,169	6,300	5,600	67,302
Idaho	6,873	2,900	1,050	4,500	15,323	3,686	54,323	7,500	9,500	75,009
Oregon	12,358	8,018	2,500	3,400	26,276	11,806	127,626	12,600	14,500	166,532
Washington	12,363	25,187	3,500	9,200	50,250	24,308	253,250	24,300	25,400	327,258
Total	52,309	36,724	13,450	22,800	125,283	44,033	486,368	50,700	55,000	636,101
U.S. Total	1,485,697	944,123	347,950	394,100	3,171,870	919,585	9,842,020	1,009,900	1,052,800	12,824,305

Table 3-4. ESTIMATED CAPITAL REQUIREMENTS AND ANNUALIZED COSTS OF IMPLEMENTING STATE PROPOSED AIR QUALITY MONITORING SYSTEMS

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region I										
Connecticut	111,198	55,793	21,050	23,700	211,741	65,141	601,734	53,400	62,800	783,075
Maine	28,746	4,670	7,750	6,500	47,666	8,996	123,702	15,300	12,800	160,798
Massachusetts	332,070	38,019	58,550	43,300	471,939	88,688	838,309	79,200	54,000	1,060,197
New Hampshire	72,422	2,664	26,050	16,200	117,336	14,861	176,587	21,300	19,600	232,348
Rhode Island	16,949	5,699	21,050	9,800	53,498	21,821	241,074	26,100	17,600	306,595
Vermont	36,921	8,741	3,200	5,400	54,262	13,893	86,269	7,200	10,700	118,062
Total	598,306	115,586	137,650	104,900	956,442	213,400	2,067,675	202,500	117,500	2,661,075
Region II										
New Jersey	38,710	54,109	3,900	8,500	105,219	68,769	470,964	40,800	54,700	635,233
New York	494,560	141,326	67,000	106,000	808,886	198,472	1,569,783	1,689,002	207,000	2,144,155
Puerto Rico	188,211	779	26,350	28,900	244,240	31,249	24,163	21,300	32,000	108,712
U.S. Virgin Isl.	8,983	697	350	500	10,530	2,295	26,129	3,300	4,400	36,124
Total	730,464	196,911	97,600	143,900	1,168,875	300,785	2,091,039	234,300	298,100	2,924,224
Region III										
Delaware	65,748	60,626	30,000	11,300	167,674	50,916	428,468	32,400	33,384	545,168
Dist. of Columbia	71,780	14,484	5,000	6,300	97,564	63,670	171,130	11,100	11,600	257,500
Maryland	192,267	81,817	46,750	28,700	349,534	101,498	828,126	72,000	63,000	1,064,624
Pennsylvania	140,385	74,672	197,500	74,900	487,457	295,022	1,800,242	116,700	119,500	2,331,464
Virginia	153,287	29,713	51,700	27,300	262,000	52,242	613,531	72,300	42,600	780,673
West Virginia	25,044	13,519	5,350	7,500	51,413	29,575	258,244	26,400	22,800	337,019
Total	648,511	274,831	336,300	156,000	1,415,642	592,923	4,099,741	330,900	292,884	5,316,448
Region IV										
Alabama	86,612	6,813	17,450	16,500	127,375	20,676	232,709	24,000	26,800	304,185
Florida	19,305	20,045	2,450	6,700	48,500	20,206	248,168	26,400	20,900	315,674
Georgia	100,254	19,561	45,300	25,200	190,315	34,074	398,557	42,000	36,800	511,431
Kentucky	393,200	54,560	93,750	126,660	668,170	116,955	1,473,275	167,700	102,600	1,860,530

Table 3-4 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region IV (cont'd)										
Mississippi	76,747	1,521	20,300	17,100	115,668	13,906	149,132	17,400	17,300	197,738
North Carolina	158,378	9,645	54,950	108,300	331,272	46,691	825,148	105,000	72,400	1,049,239
South Carolina	65,557	6,487	15,650	19,400	107,094	20,545	275,595	37,200	36,700	370,040
Tennessee	130,935	31,157	25,600	39,400	227,092	43,565	522,821	63,900	61,900	692,186
Total	1,030,988	149,789	275,450	359,260	1,815,487	316,618	4,125,405	483,600	375,400	5,301,023
Region V										
Illinois	177,603	99,267	50,650	31,500	359,020	113,083	936,509	88,800	20,700	1,159,092
Indiana	173,188	52,128	85,650	58,600	369,566	93,112	1,058,875	111,600	95,700	1,359,287
Michigan	303,135	36,843	98,200	65,200	503,378	82,223	770,081	82,500	84,200	1,019,004
Minnesota	61,730	39,152	8,550	7,800	117,232	43,266	400,480	43,500	43,900	531,146
Ohio	8,802	63,535	18,550	55,300	146,187	68,774	893,893	124,200	132,900	1,219,767
Wisconsin	185,484	27,218	26,050	21,100	259,852	55,387	464,658	47,700	49,200	616,945
Total	909,942	318,143	287,650	239,500	1,755,235	455,845	4,524,496	498,300	426,600	5,905,241
Region VI										
Arkansas	14,160	1,439	3,900	10,600	30,099	3,832	75,721	12,300	11,400	103,253
Louisiana	23,704	17,428	6,050	7,400	54,582	17,706	135,178	11,700	12,800	177,384
New Mexico	57,305	15,362	24,250	18,600	115,517	23,150	275,206	33,600	29,100	361,056
Oklahoma	39,746	14,216	16,400	17,200	87,562	23,176	280,783	40,200	38,600	382,759
Texas	2,431,845	18,552	395,700	267,700	3,113,797	421,943	2,754,810	215,100	205,300	3,597,153
Total	2,566,760	66,997	446,300	321,500	3,401,557	489,807	3,521,698	312,900	297,200	4,621,605

Table 3-4 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region VII										
Iowa	47,707	7,684	12,450	14,800	82,641	18,646	191,787	23,700	21,100	255,233
Kansas	121,629	8,915	39,150	38,400	208,094	29,454	3,880,879	45,900	22,300	3,978,533
Missouri	116,985	62,900	17,500	13,800	211,185	72,208	522,225	46,200	47,300	687,933
Nebraska	15,780	3,228	39,000	5,700	28,608	5,585	76,130	14,100	15,000	110,815
Total	302,101	82,727	73,000	72,700	530,528	125,893	4,671,021	129,900	105,700	5,032,514
Region VIII										
Colorado	175,758	13,292	25,350	16,700	231,100	40,609	336,933	34,500	35,600	447,642
Montana	27,317	4,372	6,750	8,900	47,339	8,179	85,931	9,600	7,900	111,610
North Dakota	3,223	1,357	350	1,800	6,730	1,775	34,285	6,000	6,700	48,760
South Dakota	5,197	164	1,400	3,600	10,361	1,111	22,600	3,300	2,400	29,411
Utah	48,238	30,899	6,350	13,900	99,387	34,133	265,208	22,800	15,100	337,241
Wyoming	4,956	619	700	3,400	9,675	1,458	29,261	4,500	3,900	39,119
Total	264,689	50,703	40,900	48,300	404,592	87,265	774,218	80,700	71,600	1,013,783
Region IX										
American Samoa	1,043	0	350	900	2,293	193	3,828	600	400	5,021
Arizona	69,448	22,249	15,350	11,100	118,147	31,411	262,956	24,900	31,387	350,654
California	303,400	287,372	62,500	61,500	714,772	289,632	1,792,419	119,700	151,700	2,353,451
Guam	12,094	0	2,850	3,200	18,144	2,027	21,861	2,100	2,500	28,488
Hawaii	20,884	19,817	8,200	6,100	55,001	11,119	115,550	11,100	7,300	145,069
Nevada	31,475	14,418	5,000	3,600	54,493	17,319	149,826	17,700	20,500	205,345
Total	438,344	343,856	94,250	86,400	962,850	351,701	2,346,440	176,100	213,787	3,088,028

Table 3-4 (continued)

Regions and States or U.S. Territories	Capital requirements					Annualized cost				
	New instruments	Replacement instruments	Instrument housing	Initial personnel costs	Total	Annual capital charge	Instrument operation	Data processing	Travel	Total
Region X										
Alaska	9,560	727	15,000	15,800	41,087	5,588	74,208	12,000	12,300	104,096
Idaho	12,444	7,224	2,800	7,700	30,168	8,102	98,919	15,000	17,500	139,522
Oregon	20,251	11,652	5,350	5,000	42,253	13,853	153,924	16,500	17,300	201,577
Washington	17,717	68,617	6,050	8,300	100,684	59,922	440,066	43,500	54,600	598,088
Total	59,972	88,220	29,200	36,800	214,192	87,466	767,117	87,000	101,700	1,043,283
U.S. Total	7,550,077	1,687,763	1,818,300	1,569,260	12,625,400	3,021,703	28,988,850	2,536,200	2,360,471	36,907,224

CHAPTER 4: TELEMETRIC, NONTELEMETRIC, AND PORTABLE AIR QUALITY MONITORING NETWORKS

4.1 Introduction

Air quality monitoring system configurations are limited in number only by the imagination of the system engineers who design the system. This is partially due to the variety of reasons for which ambient air quality is measured: background data gathering, trend analysis, scientific research, air quality forecasting, or one of many other reasons. Each of these monitoring categories imposes slightly different requirements on the overall network resulting in the number of different systems available today. Also encouraging the variety in system selection are the hardware manufacturers who produce systems in the form of building blocks allowing custom configuration by the customer or the in-house engineers to produce a system which will meet the requirements of the user without including expensive options not needed in his particular system.

Although the number of options available to the user is large, it is not within the scope of this chapter to describe and examine cost versus capability tradeoffs for all system types. This section is limited to the cost estimate of a fixed station network of various sizes and capabilities (in terms of number of sensors). Then these figures are examined for the effects of variations on the system, specifically the addition of telemetry capabilities, and modifications to permit moving the sites to accommodate flexible monitoring requirements. To accomplish this, agencies which have implemented various systems were contacted for cost, reliability and system capability data. The data gathered were analyzed, and representative cost figures were determined. However, before presenting the results of this analysis in section 4.2, the remainder of section 4.1 discusses system configurations, design tradeoffs and their general effects on system performance and costs for the alternative systems of interest.

4.1.1 Nontelemetric Systems

The basic system considered for the purpose of this study was the data logging type system shown schematically in Figure 4-1. Here a number of stations (or just one) are set up at remote locations for the purpose of monitoring from only a few to as many as 25 air quality monitoring sensors.

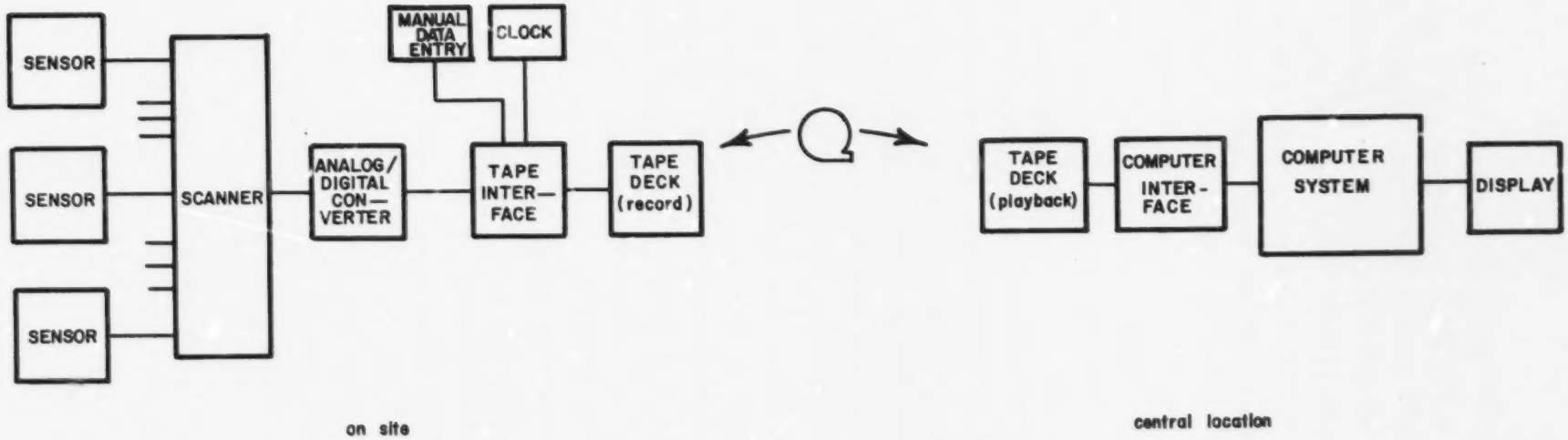

Figure 4-1. Block diagram of data logger type data acquisition system.

Data from each of the sensors are collected by means of a scanner and fed to an analog to digital (A/D) converter. The output of the A/D is then the digital representation of the input signals. As indicated in Figure 4-1, this digital representation of concentration data is one of three inputs to the magnetic tape output. The other two are: (1) time signals from the system clock and (2) manually entered data indicating system status. These tapes must be removed manually and carried to a central station for regeneration of the data. Here the data from the entire sampling period are analyzed. This batch processing permits extensive data manipulations and analyses for discrete sampling times. A disadvantage of this processing technique is that the data are not available until the tapes are returned for processing. This means that some of the data coded on tape are from 1 week to 1 month old before they are observed and evaluated. This is satisfactory for such purposes as trend monitoring for research purposes or for compliance monitoring to determine pollutant levels near suspected sources of high pollutant levels. But it is not at all satisfactory for situations in which the data must be known in (or near) real time such as in air quality forecasting or episode monitoring.

Sensors for use in this type of system are typically the same types used for any non-laboratory use. However, increased demands are made on the instrument stability and reliability due to the facts that (1) daily visits may not be made to the sites if their locations are widely scattered and (2) the data will not be observed until some later time. Thus a previous instrument failure would result in a large quantity of lost data.

In-station calibration systems may be incorporated to add confidence to the data by applying a zero and a span gas for a fixed interval daily to each gas analyzer. However, since an attendant is needed to regularly service the station to determine its operational status and to return the data tape for processing, a calibration system (without heavier components such as calibration gas bottles) may be carried from station to station at a considerable cost savings with little degradation of data quality. For this reason these systems were not priced in the typical data logger-type systems.

There are a large number of data acquisition system variations available for this type of system. Large complex systems, with their large input

capacities, high speed, and high sensitivity, have been pressed into service for air quality monitoring. However, these systems, although highly reliable, are quite expensive for air pollution data handling. Instead, more compact units are now being sold exclusively for remote monitoring. These units satisfy the basic requirements for a data acquisition system. Those requirements are determined on reference to the necessary performance parameters as listed in Table 4-1. In the case of fixed stations, system design may be tailored to the particular monitoring requirements of the program for which they are used, allowing flexibility for anticipated future expansion.

4.1.2 Telemetric Systems

A second type of system configuration used in air monitoring networks is the telemetric network shown schematically in Figure 4-2. This system is similar to the data logging type except for one major difference: The signals, once digitized, are passed over phone lines to a central location some distance away. The local tape storage capability then becomes optional; it is needed only in case of central station failure or phone line problems. This allows the monitoring of not only the measured air pollution parameters but also certain important system operation indicators such as flow rates and temperatures. This reduces the number on on-site visits and therefore costs necessary to insure the normal functioning of the instruments. However, it does not insure that the calibrations are being done accurately; therefore, some on-site calibration checks are still required periodically to insure the accuracy of the data. A second improvement brought about by the implementation of a telemetric system is an increase in the amount of valid data being taken. This results from the fact that most instrument malfunctions will be readily apparent soon after their occurrence, allowing the prompt dispatching of maintenance technicians to bring the instrument back on line.

The question of when a telemetric system should be used is not always clearly answerable. In the case where data are needed for processing as soon as they are collected--as in episode monitoring or air quality forecasting--the telemetry-type systems are necessary for meeting the requirements. However, for systems where telemetry is being considered for reasons of cost savings, its advantage is not so clear. The costs associated with telemetry are quite variable, depending on many things. Initial costs include not only the cost of the telemetric equipment itself but also the incremental cost of

Table 4-1. PERFORMANCE PARAMETERS

Input Characteristics

- Input Level Range - the magnitude and units of the input quantity which the data acquisition system will record within the accuracy specified (e.g., 0-1 volt).
- Number and Type of Inputs - the number of inputs for both digital and analog input signals.
- Special Purpose Input Provisions - any facilities for accepting inputs other than data lines with a voltage representing the measured quantity.
- Manual Inputs - number and type of switch settable or hardwired inputs for status setting or unit identification.

Sampling Characteristics

- Scan Interval or Sampling Rate - the rate at which a single channel is scanned with the instrument in normal operation.
- Programmability - capability of changing scan rate (as well as other parameters) by local or remote means (example - by computer control).

Conversion Characteristics

- Resolution - minimum change in input level which can be dependably detected and registered on output.
- Accuracy - the maximum difference between the representation of the input and the true input usually in terms of the full scale reading.

Time Annotations - means of generation of time code to be recorded with data and the format of that time code.

Pre-Storage Processing - the nature and extend of any pre-storage data processing conducted within the instrument, examples - data averaging, integration, application of transfer function.

Data Storage

- Type of Mass Storage Device - the device used for the storage of data (example - magnetic tape cassette, one-inch paper tape).
- Format of Data Stored - the format used for the data (used to establish the compatibility of the storage device with other data analysis systems.) Includes type of coding used for data, density as well as the definition of the data - (data scan interval, order of data on tape, position of time code, etc.)
- Capacity - the quantity of data which may be kept on one storage device.

Data Recovery - equipment and procedures necessary for data recovery and final format of data.

Telemetry Capabilities

- Data transfer rate
- Control Capabilities
  - Number of items within and external to the system which may changed at remote location from the central location.
  - Degree of Control (on-off or continuously variable)
- Quantity of data available by telemetry and type (real time data and/or historical data.)

Installation, Operation and Maintenance Requirements

- Includes considerations such as time required for set up of instrument, skill of operators required, attendance for maintenance and calibration required, amount of control of system available to operator.

Physical Characteristics

- Weight
- Size
- Environmental Range - the range of temperature, humidity, and particulate conditions which may be tolerated by the system in operation.
- Power Requirements
  - Type of power source accepted by the system
  - Amount of power required
  - Effects of a power failure (e.g. loss of data, loss of time or automatic resumption after power return).

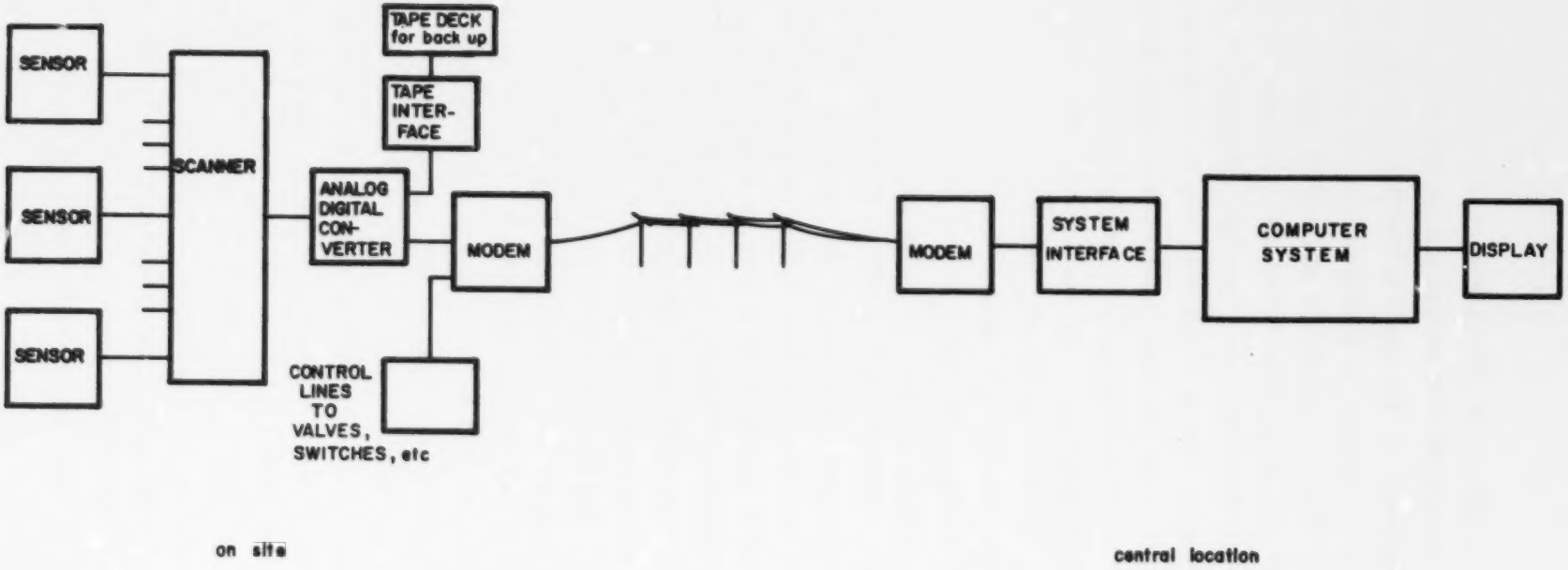

Figure 4-2. Block diagram of telemetry type data acquisition system.

a somewhat more complex or reliable data acquisition system. More complex data acquisition systems are needed due to the fact that simpler systems, while quite adequate for air quality monitoring work, are not designed for the addition of telemetry. A second source of variation in costs arises from variations in the size of the monitoring network. If the network is entirely within one city, then telephone lines may be leased, providing rather dependable and economical service. However, if a statewide network is to be considered, leased lines that are fully dedicated to the transmission of air quality data are substantially more expensive.

There are several alternative types of telemetered systems. One is simply a standard data logger system to which telemetry is added on a call-up basis. In this system the remote data acquisition system functions as a data logger, storing the data on tape. The data are made available to the central station via telemetry if the station is called. This allows an operator at a central location to check the instantaneous operational status of each station. Nonetheless, personnel still have to make the rounds of the stations to pick up data tapes, make calibrations, etc., resulting in a higher initial cost than the data logger system and a higher operating cost than the telemetry system using dedicated lines.

A second type of telemetry system is one which employs a data logger with read-write tape units and remote control capabilities. This enables the operator from a central station to call each station periodically (daily), command the deck to rewind and play back the data recorded over the past recording period. This type of system, if reliably designed, saves periodic trips to pick up the data tapes. This is a somewhat doubtful savings, however, in that periodic trips are made to each station for calibration or maintenance purposes anyway and no additional costs are involved in bringing in the magnetic tape as well. The use of this system arises in cases where data may not be needed in real time but are needed more often than every other day -- for example, in cases where air quality forecasts are to be made twice daily and the data are needed only for those forecasts. Here the data could be called up an hour before the forecasts are due, processed, and displayed for evaluation. Cost savings may be realized in this type of system if reliable phone communications to the remote sites are available and an operating procedure is set forth to allow the telemetry setup to do the data gathering rather than technicians on on-site visits.

Still another variation in the telemetric systems incorporates the option of remotely controlling devices external to the data acquisition system at the remote site. A successful implementation of this system is necessary before the full cost of the dedicated (or even dial-up) systems can be offset by a savings in labor. This system not only saves the time costs of picking up the data and evaluating the status of station performance but also reduces the number of calibration trips in allowing them to be done either by computer control or, remotely, from the central station. For this reason, it was this configuration that was selected for the telemetric system cost estimates presented in this chapter.

4.1.3 Station Portability

The provision for remote station portability is still another option which may be exercised in the design of an air quality monitoring system. Typically, the agency doing air quality monitoring is either a municipal, county, state, or federal agency. This means that the agency may obtain space in already existing buildings belonging to other agencies in an effort to save the cost of several physical stations. However, this savings may not materialize because troubles are often encountered when one tries to install a number of samplers in already existing structures. These difficulties include tailoring the installation of racks, sample manifolds, and other hardware to the particular room being used. Consequently, each new site location may require a unique design and the attendant high costs of custom work. However, if the stations are assembled on skids (see Figure 4-3) or in trailers at a single location, one design can be used, yielding a substantial savings in time expenditures for the procurement of parts and for station assembly. For these reasons this study incorporates only cost estimates for shelters which may be assembled, moved on site, and then fitted with the instrumentation. The same figures would apply for trailers except for the additional cost of a trailer over a shelter (that increment is approximately $3000 for the size installation discussed herein). It should be remembered that, even though a system is portable, an additional expense will be incurred in moving the system to a new site. This expense can be reduced to that of manpower and utility hookup by using jacks to raise the building and a small, flat, low trailer to slide under the building. The

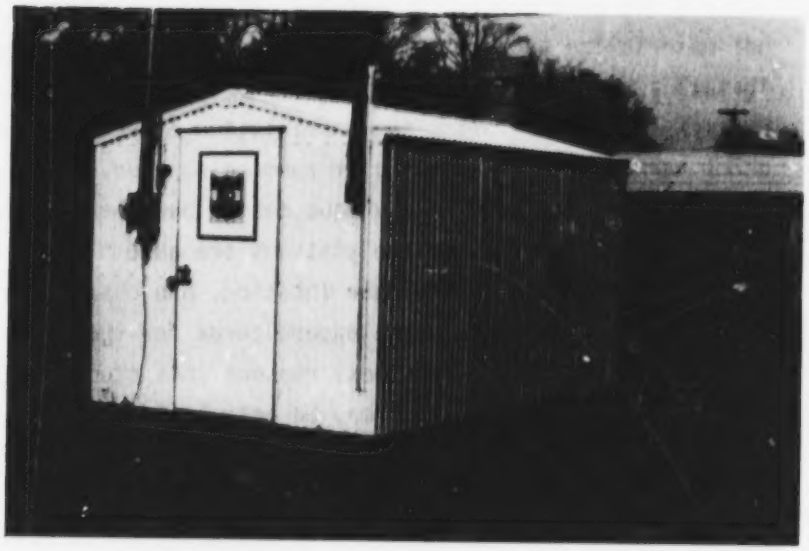

Figure 4-3. Typical installation of portable shelters on skids.

trailer then can be towed to a new site connected to the proper utilities and brought on-line.

Mobile vans were not considered in this study since their high initial costs make them impractical except for infrequent cases in which high mobility is necessary.

4.2 Cost Analyses

4.2.1 Sources of Data and Assumptions

The major sources of data used in the following cost analyses are interviews with air pollution control agency personnel and RTI's experience in the operation of air quality monitoring instruments. Specifically, these sources include:

1) The Allegheny County Bureau of Air Pollution Control (Pennsylvania) which is presently operating an automatic telemetered air monitoring network with remote calibration capability consisting of seven remote stations and a central station. RTI personnel spent two days in Pittsburg, Pa., discussing network operation and costs with Allegheny County personnel.
2) The Research Triangle Institute's experience in installing and operating a network of seven remote stations in Chattanooga, Tenn., using on-site data logging systems. This included purchasing and installing the sensors, data loggers, and the portable shelter. The stations have been installed and operating for over a year.
3) The State of Pennsylvania Bureau of Air Pollution which is operating a system of 17 sites in special-design trailers. Data are collected over dedicated phone lines by a computer at the central station.
4) The Milwaukee County Department of Air Pollution Control which monitored pollutant levels by manual methods at points throughout the county.
5) The St. Louis County Department of Air Pollution which operates a telemetry type system of approximately seven stations. Data are obtained by means of a computer at a central location, displayed, and placed on magnetic tape for further processing.
6) New York State which utilizes time-shared computer monitoring of multiple stations over dedicated phone lines.

7) Current vendor files for latest computer and special electronics costs.

The assumptions made and the network configurations used in the cost analysis are summarized in Table 4-2. A summary of the cost data is contained in Table 4-3. Costs are divided into four categories for discussion purposes. The four categories are 1) fixed hardware, 2) fixed non-hardware, 3) variable non-personnel, and 4) variable personnel. Cost elements in each of these categories are now discussed in detail using an outline format.

FIXED HARDWARE

A. Remote Electronics

1. Basic Data Acquisition System - For this system it was assumed that two to three channels of data storage are needed for each instrument to monitor the operation of the station and the parameter being measured. Hence, for sites with four to seven sensors, a 16-channel system may be used while a 10-sensor site would require a more sophisticated unit. With the addition of telemetry, increased demands are made on the system's reliability, scale, and capability resulting in a substantial cost increase in the small-scale systems and yet a minor increase in large-scale. This is due to the lack of small units with telemetry capability inherent.
2. Remote Calibration Capability - This hardware option is available to reduce the number of on-site visits necessary to maintain calibration. In this study the following configuration was assumed: one $2400 removable calibration system per station along with two mass flowmeters (for monitoring flow rates in the system and for insuring the accuracy of calibration gas levels).
3. Battery Backup - This equipment is necessary to preserve time data in nontelemetry systems and to maintain answering capability in telemetry models. A $1000 unit will generally provide this capability while avoiding transients (temporary oscillations in power) when circuit changeovers occur.
4. Sensors - Three basic equipment configurations were assumed. The instruments contained in each configuration are summarized

Table 4-2. SUMMARY OF NETWORK CONFIGURATIONS AND ASSUMPTIONS

1. Cost Categories

   a) Fixed hardware
   b) Fixed non-hardware
   c) Variable non-personnel
   d) Variable personnel

2. Network Types

   a) Telemetering Networks
      1) Automatic sensors
      2) On-site signal conditioning
      3) Telemetry
      4) Automatic calibration (zero and span) capabilities
      5) Automatic data analysis and printout (computer)
      6) Portable remote station

   b) Non-Telemetry

      1) Automatic sensors
      2) On-site data logging
      3) Automatic data analysis (computer)
      4) Manual zero and span equipment on-site
      5) Portable remote station

3. Personnel Salary Plus Benefits Range Per Year

   a) Administrator 15-20K
   b) Engineer/Chemist 12-16K
   c) System Analyst/Programmer 8-14K
   d) Technician (Maintenance/Calibration) 8-12K
   e) Keypunch Operator/Secretary 5-7K

4. Sensor Combinations

   a) (S=4) Sulfur dioxide (SO_2), fine particulate (FP), wind speed (WS), and wind direction (WD)
   b) (S=7) SO_2, FP, WS, WD, carbon monoxide (CO) ozone (O_3), and nitrogen dioxide (NO_2)
   c) (S=10) SO_2, FP, WS, WD, CO, O_3, NO_2, total hydrocarbons (THC), temperature (T), relative humidity (RH)

5. Number of Remote Stations (L = Locations)

   a) L=5
   b) L=10
   c) L=20
   d) L=30

6. Cost figures; (Telemetered) nontelemetered where only one cost figure is entered without parenthesis it is applicable to both network types, i.e., telemetered and nontelemetered.

7. Average distance between stations is 8 miles.

Table 4-3. SUMMARY COST DATA

COST ELEMENT NAME	L = 5			L = 10			L = 20			L = 30			Assumed Life of Item (Years)
	S = 4	S = 7	S = 10	S = 4	S = 7	S = 10	S = 4	S = 7	S = 10	S = 4	S = 7	S = 10	
FIXED HARDWARE				Cost X 1000									
A. Remote Station													
1. Remote Electronics													
a) Basic Data Acq. System	(55) 25	(55) 25	(55) 50	(110) 50	(110) 50	(110) 100	(220) 100	(220) 100	(220) 200	(330) 150	(330) 150	(330) 300	10
b) Calibration (Remote Capability)	(40)	(40)	(40)	(80)	(80)	(80)	(160)	(160)	(160)	(240)	(240)	(240)	10
c) Battery Backup	5	5	5	10	10	10	20	20	20	30	30	30	10
2. Sensors	29	87	144.5	58	174	289	116	348	578	174	522	867	5
3. Test, Maintenance, and Calibration Equipment	5.1	6.8	7.3	10.1	13.6	14.4	20.2	27.2	28.7	30.3	40.8	43.1	5
4. Initial Spares	5.9	19.4	28.9	11.8	38.8	57.8	23.2	77.6	115.6	34.8	116.4	173.9	5
5. Site Cost (Building, Building Modification, and Site Installation	17.5	17.5	17.5	35	35	35	70	70	70	105	105	105	10
B. Control Station													
1. Computer with Line Printer, Disc, and Reader for Magtape from Field Stations	75	75	75	75	75	75	75	75	75	75	75	75	10
2. Interface, Remote Control Unit for Receiving Data from Remote Sites	(16	(16	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	10
FIXED NON-HARDWARE													
1. Specification Preparation and Program Management	3	3	3	3	3	3	3	3	3	3	3	3	10
2. Software (Programmer)	3	3	3	3	3	3	3	3	3	3	3	3	10
3. Documentation	3	3	2	2	2	3	3	2	3	2	2	3	10
4. Training	5	5	5	5	5	5	5	5	5	5	5	5	10
5. Remote Station Installation, Agency Labor	6	7	9	12	15	18	24	30	36	36	45	72	10
6. Central Station Installation, Agency Labor	4	4	4	4	4	4	4	4	4	4	4	4	10
VARIABLE, NON-PERSONNEL													
1. Utilities, Remote Station (Elect., Heat, Cooling)	3.7/yr	3.7/yr	4.1/yr	5.4/yr	7.4/yr	8.1/yr	10.8/yr	14.8/yr	16.2/yr	10.8/yr	18.5/yr	20.3/yr	
2. Utilities, Communication	3.7/yr	3/yr	3.3/yr	5.4/yr	6/yr	6.6/yr	10.8/yr	12/yr	13.2/yr	16.3/yr	18/yr	19.8/yr	
3. Transportation, Local	(0.4/yr) 1/yr	(.5/yr) 1.1/yr	(.75/yr) 1.3/yr	(.75/yr) 1/yr	(1/yr) 2.3/yr	(1.5/yr) 2.5/yr	(1.5/yr) 4/yr	(2/yr) 4.5/yr	(3/yr) 5/yr	(2.3/yr) 3.8/yr	(3/yr) 4/yr	(4.5/yr) 6.8/yr	
4. Supplies (paper and parts)	3.4/yr	8.4/yr	10.9/yr	6.8/yr	16.8/yr	21.8/yr	13.5/yr	33.5/yr	43.5/yr	20.3/yr	50.3/yr	65.3/yr	
5. Facilities (Rent)	1/yr	1./yr	1./yr	2/yr	2/yr	2/yr	4/yr	4/yr	4/yr	6/yr	6/yr	6/yr	
VARIABLE, PERSONNEL													
1. Administrator	12/yr	13.5/yr	15/yr	14/yr	17/44	20/yr	18/yr	34/yr	30/yr	22/yr	31/yr	40/yr	
2. Engineer/Chemist	1.9/yr	3.3/yr	4.7/yr	3.7/yr	6.5/yr	9.3/yr	7.5/yr	13.1/yr	18.6/yr	11.2/yr	19.6/yr	28/yr	
3. System Analyst/ Programmer	12/yr	12/yr	12/yr	12/yr	24/yr	24/yr	24/yr	36/yr	36/yr	36/yr	48/yr	48/yr	
4. Technician (Maintenance/Calibration)	(13/yr) 39/yr	(32/yr) 50/yr	(33/yr) 71/yr	(26/yr) 38/yr	(46/yr) 100/yr	(66/yr) 143/yr	(53/yr) 115/yr	(93/yr) 200/yr	(133/yr) 284/yr	(80/yr) 174/yr	(140/yr) 300/yr	(200/yr) 429/yr	
5. Support (Key Punch/ Sec.)	6/yr	6/yr	6/yr	6/yr	6/yr	6/yr	6/yr	12/yr	12/yr	12/yr	18/yr	18/yr	
TOTALS	(86/yr) 94/yr	(122/yr) 141/yr	(151/yr) 183/yr	(134/yr) 151/yr	(218/yr) 258/yr	(274/yr) 340/yr	(258/yr) 296/yr	(397/yr) 478/yr	(514/yr) 647/yr	(348/yr) 402/yr	(593/yr) 655/yr	(705/yr) 907/yr	

Key: all single entries apply to both telemetric and nontelemetric systems. The parenthesized entries refer specifically to telemetric systems.

according to the pollutant or meterological parameter each measures in Groups A, B, and C below. (The abbreviations of Groups A, B, and C are used in Table 4-2.)

Group A	Group B	Group C
SO_2	CO	Total hydrocarbons (THC)
Fine particulate (FP)	O_3	Temperature (T)
Wind speed (WS)	NO_2	Relative humidity (RH)
Wind direction (WD)		

All sensor purchase cost data were displayed in Chapter 2 (Tables 2-1 through 2-8).

5. Test, Maintenance, and Calibration Equipment - Projections of the requirements for this equipment assumed that the hardware could be used at an average of five sites. This equipment includes tools, calibration equipment and test equipment. Increments in cost as the number of sensors increases results from additional calibration requirements.
6. Site Cost - This category includes the costs of a heated and air conditioned shelter installed on-site.
7. Initial Spares - Spare parts cost projections assume that one spare instrument for every five in place is necessary to replace those which are down and must be returned to a central location for repair.

B. Central Station

1. Computer - Computer costs consist of outlays for a dedicated mini-computer with high speed input/output devices, disc storage, and tape capability. An executive system allows access to the data without disturbing the program which scans the stations.
2. Interface Unit - This unit is used for telemetry only. It received data from remote stations, decodes it, and feeds it to the computer. Also, it allows commands from the computer or the operator to be sent to the remote station.

FIXED NON-HARDWARE

1. Specification Preparation and Program Management - The agency must specify the desired present and future capabilities of the system and general terms. Actual technical specifications will be indicated by the vendor within the agency's resource constraints. The agency must also oversee and manage the installation and checkout of the system. Three engineering man-months at a direct rate of $1700 per month is allotted for this purpose.
2. Software - It is assumed that most of the necessary software will be provided by the vendor as part of the initial system. Three months of a programmer's time were assumed necessary to gain familiarity with the system and to write any additional programs to put the system on-line. The programmer's time is valued at a direct rate of $1000 per month.
3. Documentation - The documentation of the air quality monitoring system, as new components are installed, is necessary for the agency to operate successfully the system after the vendor has completed installation. Two months of technical time at a direct rate of $1000 per month are assumed necessary for this purpose.
4. Training - In going from a manual to an automatic network, some formal training is usually desirable, if not necessary. Once the system is operating, the cost of a continuous training program would be included as part of the operating cost. Initial training of one or two key personnel is estimated to cost about $5000.
5. Remote Station Installation, Agency Labor - Installing electronics, sensors, and calibration equipment in a remote station is estimated to require about two man-months of an agency technician's time and about one man-month of vendor time. The vendor's time is included in the initial cost of the equipment. The agency's cost for a technician with an average annual salary plus benefits of $9000 is estimated to be $1200, $1500, and $1800 for a station with four, seven, and ten sensors, respectively.
6. Central Station Installation, Agency Labor - The computer, peripherals, and interface equipment are installed and checked by the respective vendors. The agency labor involves having a technician work with

the vendors as a training process and for coordination of the total installation process. The agency labor is estimated to consist of about four man-months, equally divided between an engineer and a technician at average annual salaries and benefits of $14,000 and $10,000, respectively. This total cost then would be about $4000 and would be virtually independent of the size of the network.

VARIABLE NON-PERSONNEL

1. Utilities, Remote Station - Electrical power for the sensors, data acquisition system, temperature control, and lights is estimated to be about $2700 per year for a network with five stations (L=5) and four sensors (S=4) per station. This is an average of $540 per year per station, or $45 per month per station.
2. Utilities, Communications - An automatic network with dedicated telephone lines (local lines) has a typical cost of about $50 per month per site. For this cost evaluation a value of $45 per month was used for a site with 4 sensors, $50 per month for a site with 7 sensors, and $55 for a station with 10 sensors.
3. Transportation, Local - An automatic network with telemetry and automatic remote calibration (zero and span) capabilities is estimated to require an average of 1.5, 2, and 3 visits per week for stations with 4, 7, and 10 sensors, respectively. These visits are for performing dynamic multi-point calibrations, maintenance, and general observations necessary to assure the collection of valid and high-quality data.

   A semi-automatic network with on-site data logging and with no automatic calibration system is estimated to require an average of 4, 4.5, and 5 visits per week for a station with 4, 7, and 10 sensors, respectively. All transportation costs in Table 4-3 are based on an average distance of 8 miles between stations.
4. Supplies - Expenditures for supplies such as strip chart paper, paper tapes, and replacement parts for the sensors are estimated to be about $675 per year, $1,675 per year, and $2,175 per year for a station with 4, 7, and 10 sensors, respectively.
5. Facilities - Rent and repair on a portable shelter is estimated at $200 per year. In all the networks visited on this project, no rent was paid for the shelter site.

VARIABLE PERSONNEL

1. Administrator - The cost of an administrator responsible for the functioning of a network is estimated in dollars per year as

$$\$100\ (L \times S) + \$10,000$$

where L = the number of stations in the network, and
S = the number of sensors in a station.

2. Engineer/Chemist - Engineering requirements are estimated as one professional for each factor or fraction of a factor of L x S = 150, with an estimated yearly salary plus benefits of $14,000.
3. System Analyst/Programmer - The continuing time requirement for programming, data processing, data validation and data storage is estimated to require one system analyst for each factor or fraction of a factor of L x S = 50, with an estimated yearly salary plus benefits of $12,000 per year.
4. Technician (Maintenance/Calibration) - One technician for each factor or fraction of a factor of L x S = 15 at an average annual salary plus benefits of $10,000 is the estimated maintenance/calibration requirement.
5. Support (Keypunch/Secretary) - Keypunch and secretarial time combined is estimated to require one full time person for every factor or fraction of a factor of L x S = 100. An average annual salary plus benefits of $6000 is assumed.

4.2.2 Nontelemetric Data Acquisition Systems

Cost estimates given in Table 4-3 include those of a nontelemetric network in which the air pollution data are recorded on magnetic tape at the remote station and transported by hand to a central station for automatic data analysis by computer. Also, all calibrations including daily zero and span checks are performed manually. The network configuration is illustrated in Figure 4-1.

The primary differences in costs for nontelemetric and telemetric networks are:

1) a higher initial installation cost for a telemetric network, and
2) a higher continuing labor cost for a nontelemetric network.

4.2.2.1 Initial Installation and Incremental Expansion Costs. Initial installation costs include all items under the headings of Fixed Hardware and Fixed Non-Hardware in Table 4-2. These costs are shown graphically in Figure 4-4. The installation cost is greater for telemetric networks than for nontelemetric networks as can be seen from Figure 4-4. However, the difference in cost for the two types of networks decreases as the number of sensors per remote station increases.

Since the cost figures can vary significantly from application to application and since those given in Table 4-3 are averages of data obtained from several networks, it was felt that a straight line approximation of the data (as in Figure 4-4) is acceptable. This allows for interpolation of cost as a function of the number of remote stations. Also, rough cost estimates as a function of the number of sensors (from 4 to 10) in a remote station can be obtained by interpolation from the vertical axis for a fixed number of remote stations.

4.2.2.2 Personnel and Operating Costs. Operating costs are listed under the headings of Variable, Non-Personnel and Variable Personnel in Table 4-3 as average annual costs. Figure 4-5 is a graphical presentation of the operating costs in terms of the number of remote stations (L) and the number of sensors (S) per station for both telemetric and nontelemetric networks.

Results of the cost analysis show, as can be seen from Figure 4-5, that the operating cost is higher for the nontelemetric networks and that the cost differential increases as the number of sensors per station increases.

4.2.2.3 Total Average Annual Costs. Initial installation costs, prorated over five years for sensors and calibration equipment and over ten years for other items, are combined with the operating costs and given in Figure 4-6. From Figure 4-6 it can be seen that:

1) telemetered networks are less costly for the time range studied,
2) the difference in costs becomes more pronounced as a) the number of sensors per station increases and b) the number of remote stations increases, and
3) at the lower end (corresponding to L=5, S=4) the costs are approximately the same.

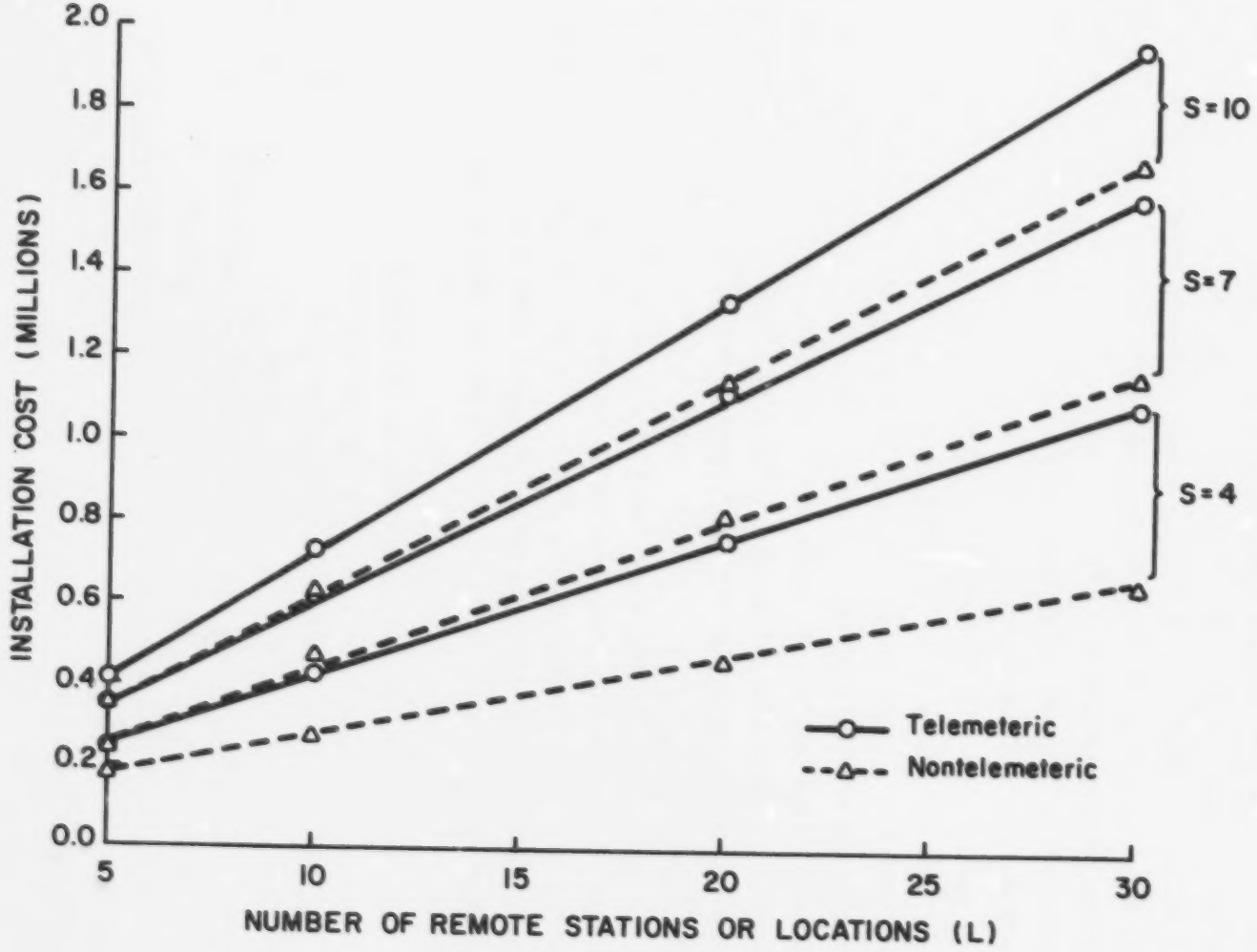

Figure 4-4. Installation cost of a network as a function of the number of stations (L) and the number of samplers (S).

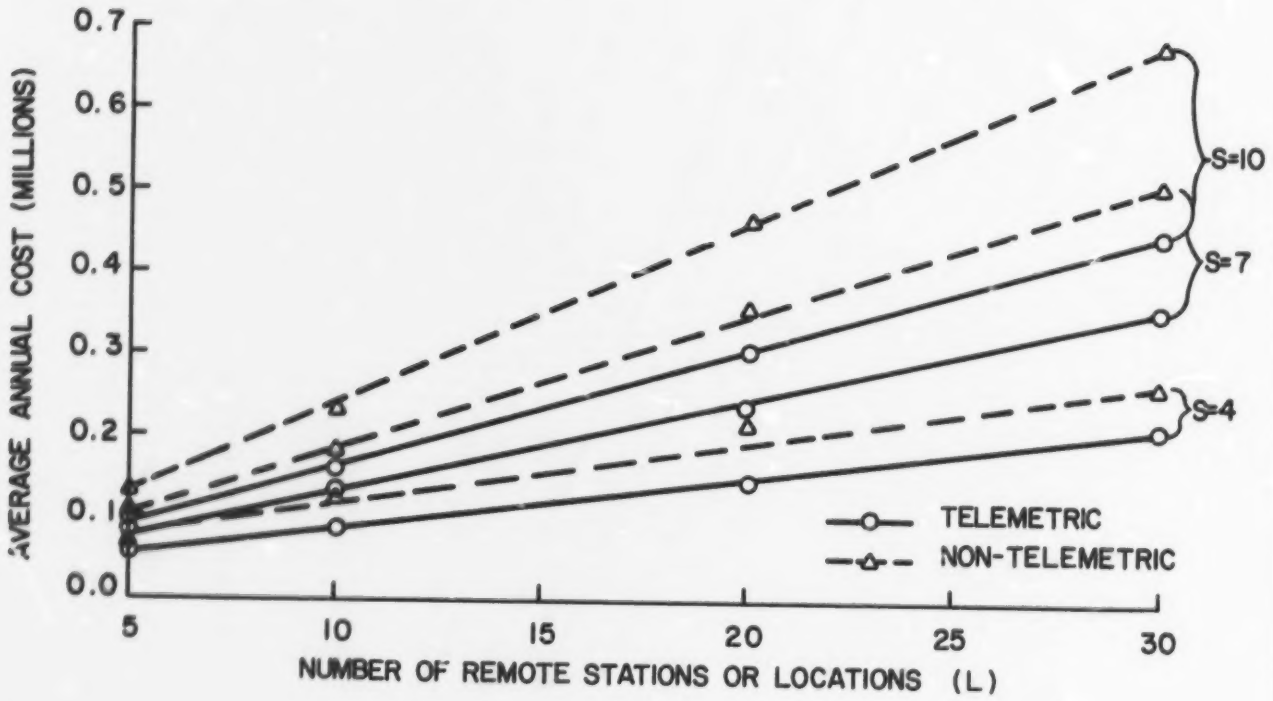

Figure 4-5. Average annual operating costs of a network as a function of the number of stations (L) and the number of samplers (S).

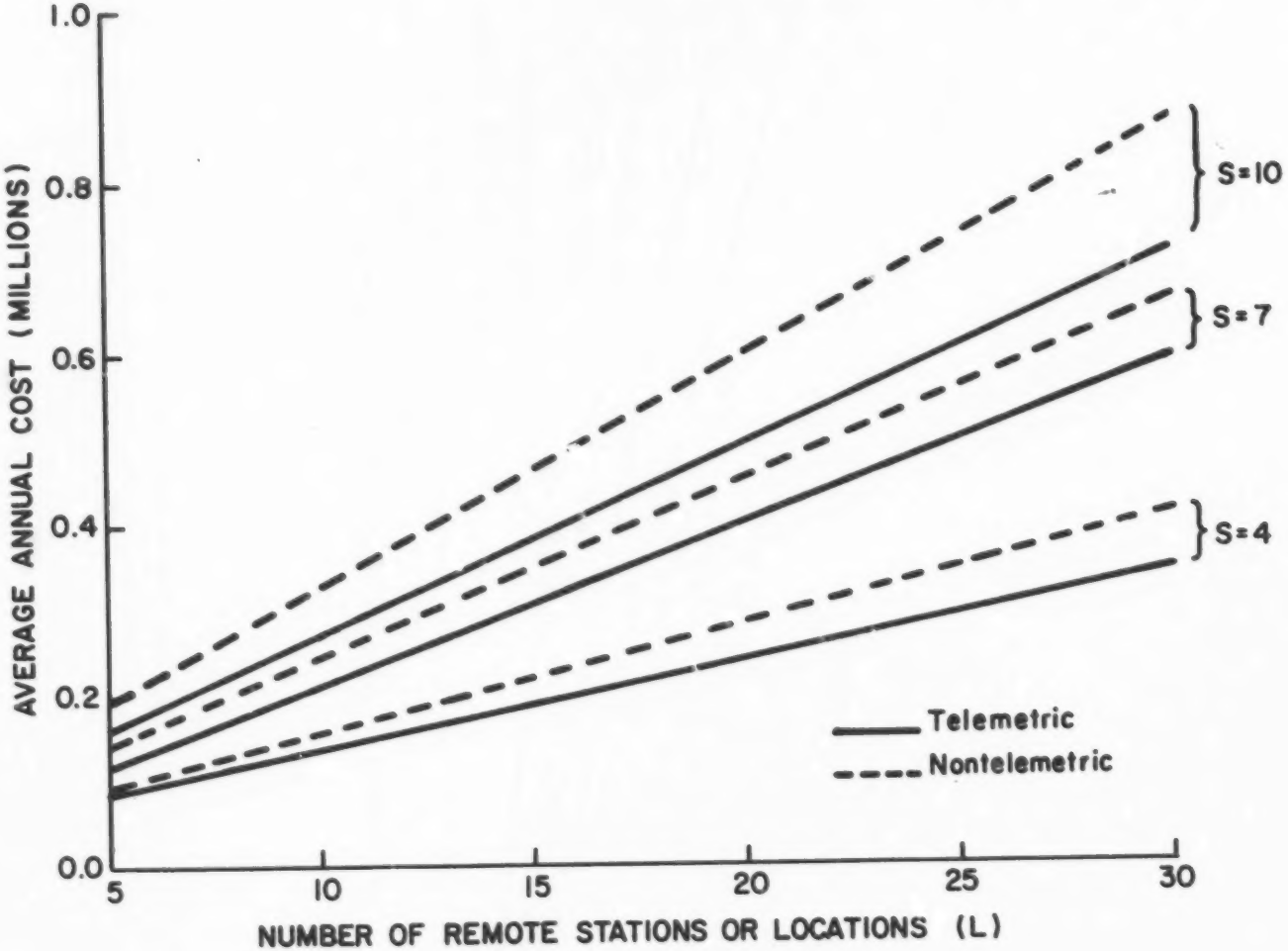

Figure 4-6. Total average annual cost of a network as a function of the number of stations (L) and the number of samplers (S).

These results are, of course, dependent on the original cost estimates. To be valid for any one particular application, specific local cost data would have to be used.

4.2.2.4 Reliability of Existing Systems. The important components of a nontelemetric on-site data logging network are listed here, roughly in the order of decreasing reliability:

1) central computer,
2) data logger, and
3) sensors.

Sensor reliability is dependent on the type of sensor in question. Results of an instrument evaluation program conducted by RTI under contract to EPA[1] involving 27 ambient air analyzers, many of which were prototype instruments based on newly developed measurement techniques or first production models, are given in Table 4-4. Direct comparisons cannot be made between instruments of the same type or between different types since the evaluation time varied for the different instruments. Also, in some instances, the evaluation time was too short to establish a meaningful reliability figure.

From the data in Table 4-4, combined with RTI's experience with other ambient air monitoring projects, an estimate of sensor reliability ranging from 0.9 to 0.95 (i.e., 5 to 10 percent downtime) for a typical air pollution network seems reasonable.

Data logging systems also vary in reliability. For a data logging system of fixed capability, increased reliability can generally be obtained at additional costs. One ambient air monitoring program conducted by RTI[2] and composed of 7 remote stations operating for 1 year showed that 78 percent of the data could be recovered from the data loggers. After minor engineering

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[1] C. E. Decker, T. M. Royal, and J. B. Tommerdahl, "Field Evaluation of New Air Pollution Monitoring Systems," Final Report, Research Triangle Institute, Contract No. CAP-70-101, Environmental Protection Agency, 1972.

[2] C. E. Decker, T. M. Royal, and J. B. Tommerdahl, "Program for Upgrading the NO_2 Instrumentation Employed in the 1972 Chattanooga NO_2 Exposure Study," Final Report, Research Triangle Institute CRC-APRAC Project No. CAPM-10-71, Coordinating Research Council.

Table 4-4. OPERATIONAL SUMMARY OF AMBIENT AIR ANALYZERS

	Number of Days Tested	Ambient Monitoring Time (%)	Calibration Time (%)	Downtime (%)
Bendix Env. Sci. O_3	94	94.7	2.9	2.4
Bendix Process O_3	74	94.3	2.4	3.3
RTI (Solid Phase) O_3	185	94.1	2.7	3.2
Dasibi O_3	32	98.5	1.4	0.1
Mast O_x	256	94.2	3.3	2.5
Technicon O_x	256	87.5	4.5	8.0
Beckman O_x	65	90.0	5.5	4.5
Beckman NO_2	154	81.1	5.9	13.0
Technicon NO_2	90	78.4	3.6	18.0
Thermo Electron NO_2	65	82.1	6.4	12.5
Aerochem NO	146	82.8	2.9	14.3
Beckman NO	84	41.5	33.9	24.6
Thermo Electron NO	65	83.6	6.9	9.5
Beckman SO_2	95	94.9	3.6	1.5
Leeds & Northrup SO_2	184	93.5	2.6	3.9
Melpar SO_2	260	93.5	3.0	3.5
Philips SO_2	260	86.0	2.4	11.6
Pollution Monitor SO_2	124	57.3	2.8	39.9
Technicon SO_2	90	74.4	4.0	21.6
Tracor SO_2	205	67.0	2.7	30.3
Technicon H_2S	90	47.3	1.9	49.2
Tracor H_2S	199	67.0	2.7	30.3
Beckman THC	148	72.0	2.1	25.9
Power Design THC	139	85.0	1.0	14.0
Beckman CO	148	72.0	2.1	25.9
Mine Safety Appliances CO	124	82.5	3.7	13.8
Beckman CH_4	148	72.0	2.1	25.9

modifications to the systems, a 90-percent recovery is expected for the following year. It is felt that the reliability of percent of recovered data should exceed 90 percent in a typical network.

4.2.3 Telemetric Systems

Table 4-3 also includes estimates for operation of a telemetric network as illustrated in Figure 4-2. In this network an automatic zero and span calibration system, controlled by a central computer, is used in each remote station. Real time air pollution data are transmitted over dedicated phone lines from the remote station to a central station.

4.2.3.1 Initial Installation and Incremental Expansion Costs. Initial installation costs are given in Table 4-3 and are summarized in Figure 4-4. See subsection 4.2.2.1 for further discussion.

4.2.3.2 Personnel and Operating Costs. Operating costs are listed in Table 4-3 and presented graphically in Figure 4-5. See subsection 4.2.2.2 for further discussion.

4.2.3.3 Total Average Annual Costs. Total average annual costs are given in Figure 4-6. See subsection 4.2.2.3 for further discussion.

4.2.3.4 Reliability of Existing Systems. In order of decreasing reliability, the major components of a telemetric monitoring network may be ranked:

1) central computer,
2) telemetric system, and
3) sensors.

In networks where real time data are transmitted to a central computer for analysis, it is necessary to have a back-up unit to record the data for future analysis in case of computer malfunctions. Such a system avoids data losses due to computer malfunctions and results only in an inability to obtain real time data.

The largest source of data loss attributable to the telemetry system is the telephone lines used to transmit the data. It is not uncommon to lose 5 percent of the data due to phone line deficiencies. However, these data can usually be recovered from the station strip chart recorder.

4.2.4 Portable/Mobile Station Costs

Portable, as used here, implies that the station can be picked up with a crane or with jacks for loading on a trailer or truck for transporting to

another location. A mobile station implies that the structure is on wheels. For this analysis only non-motorized mobile stations, such as trailers, are considered.

The portable/mobile stations are equipped for connection to regular electrical power lines. It is not recommended that a station use its own power supply due to the possibility of influencing the pollutant levels being measured.

4.2.4.1 Portable Station. A portable shelter 8'W x 12'L x 7'H as shown in Figure 1-3 can be purchased and placed on site for $2500 to $3500. $3500 was the average cost experienced in placing 7 stations in Chattanooga, Tennesse, and is the cost given by the Allegheny County Bureau of Air Pollution Control for installing portable stations in and around Pittsburg, Pennsylvania. Larger shelters would, of course, cost more.

4.2.4.2 Mobile Stations. Allegheny County had some of its telemetric remote stations in trailers. The initial cost of such a station was approximately $6500 compared to $3500 for the portable station. Unless the station is expected to be moved quite frequently, say once every six months, the extra cost is not justified. In many instances the portable stations are as easy and as cheap to move as are the mobile stations.

CHAPTER 5: BIBLIOGRAPHY

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Appendix A: FEDERAL AIR QUALITY SURVEILLANCE REQUIREMENTS

Table A-1 summarizes the minimum requirements that must be achieved by all regional air quality monitoring networks. The reference methods, required sampling frequencies, and site requirements are indicated by pollutant and by regional priority classification.

Table A-1. AIR QUALITY SURVEILLANCE SYSTEM MEASUREMENT, SAMPLING, AND SITE REQUIREMENTS

Classification of region	Pollutant	Measurement method [1]	Minimum frequency of sampling	Region population	Minimum number of air quality monitoring sites [2]
I	Suspended particulates	High volume sampler	One 24-hour sample every 6 days [3].	Less than 100,000	4.
				100,000-1,000,000	4+0.6 per 100,000 population.[4]
				1,000,001-5,000,000	2.5+0.25 per 100,000 population.[4]
				Above 5,000,000	12+0.16 per 100,000 population.[4]
		Tape sampler	One sample every 2 hours		One per 250,000 population [5] up to eight sites.
	Sulfur dioxide	Pararosaniline or equivalent [6]	One 24-hour sample every 6 days (gas bubbler).[3]	Less than 100,000	3.
				100,000-1,000,000	2.5+0.5 per 100,000 population.[4]
				1,000,001-5,000,000	6+0.18 per 100,000 population.[4]
				Above 5,000,000	11+0.06 per 100,000 population.[4]
			Continuous	Less than 100,000	1.
				100,000-5,000,000	1+0.13 per 100,000 population.[4]
				Above 5,000,000	6+0.03 per 100,000 population.[4]
	Carbon monoxide	Nondispersive infrared or equivalent.[7]	Continuous	Less than 100,000	1.
				100,000-5,000,000	1+0.15 per 100,000 population.[4]
				Above 5,000,000	6+0.03 per 100,000 population.[4]
	Photochemical oxidants	Gas phase chemiluminescence or equivalent.[7]	Continuous	Less than 100,000	1.
				100,000-5,000,000	1+0.15 per 100,000 population.[4]
				Above 5,000,000	6+0.03 per 100,000 population.[4]
	Nitrogen dioxide	24-hour sampling method (Jacobs-Hochheiser method).	One 24-hour sample every 14 days (gas bubbler).[3]	Less than 100,000	3.
				100,000-1,000,000	4+0.6 per 100,000 population.[4]
				Above 1,000,000	10.
II	Suspended particulates	High volume sampler	One 24-hour sample every 6 days [3].		3.
		Tape sampler	One sample every 2 hours		1.
	Sulfur dioxide	Pararosaniline or equivalent [6]	One 24-hour sample every 6 days (gas bubbler).[3]		3.
			Continuous		1.
III	Suspended particulates	High volume sampler	One 24-hour sample every 6 days [3].		1.
	Sulfur dioxide	Pararosaniline or equivalent [6]	One 24-hour sample every 6 days (gas bubbler).[3]		1.

[1] Equivalent to 61 random samples per year.
[2] Equivalent to 26 random samples per year.
[3] Total population of a region. When required number of samplers includes a fraction, round-off to nearest whole number.
[4] Equivalent methods are: (1) Gas Chromatographic Separation—Flame Photometric Detection (provided Teflon is used throughout the instrumental system in parts exposed to the air stream), (2) Flame Photometric Detection (provided interfering sulfur compounds present in significant quantities are removed), (3) Coulometric Detection (provided oxidizing and reducing interferences such as O_2, NO_2, and H_2S are removed), and (4) the automated Pararosaniline Procedure.
[5] Equivalent method is Gas Chromatographic Separation—Catalytic Conversion—Flame Ionization Detection.
[6] Equivalent methods are (1) Potassium Iodide Colorimetric Detection (provided a correction is made for SO_2 and NO_2), (2) UV Photometric Detection of Ozone (provided compensation is made for interfering substances), and (3) Chemiluminescence Methods differing from that of the reference method.
[7] It is assumed that the Federal motor vehicle emission standards will achieve and maintain the national standards for carbon monoxide, nitrogen dioxide, and photochemical oxidants; therefore, no monitoring sites are required for these pollutants.
[8] In interstate regions, the number of sites required should be prorated to each State on a population basis.
[9] All measurement methods, except the Tape Sampler method, are described in the national primary and secondary ambient air quality standards published in the FEDERAL REGISTER on Apr. 30, 1971 (36 F.R. 8186). Other methods together with those specified under footnotes (d), (e), and (f) will be considered equivalent if they meet the following performance specifications:

Source: Federal Register, XXXVI, No. 158 (August 14, 1971), p. 15492.

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